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THE AGRICULTURAL RESEARCH COMMERCIALIZATION ACT OF 1988

HEARING

BEFORE THE

SUBCOMMITTEE ON AGRICULTURAL RESEARCH AND GENERAL LEGISLATION

OF THE

COMMITTEE ON AGRICULTURE, NUTRITION, AND FORESTRY
UNITED STATES SENATE

ONE HUNDREDTH CONGRESS

SECOND SESSION

ON

S. 2413

A BILL TO ESTABLISH REGIONAL CENTERS FOR THE COMMERCIAL DEVELOPMENT OF NEW INDUSTRIAL FARM AND FOREST PRODUCTS, AND FOR OTHER PURPOSES

JUNE 6, 1988

Printed for the use of the
Committee on Agriculture, Nutrition, and Forestry

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THE AGRICULTURAL RESEARCH COMMERCIALIZATION ACT OF 1988—S. 2413

MONDAY, JUNE 6, 1988

U.S. SENATE, SUBCOMMITTEE ON AGRICULTURAL RESEARCH AND GENERAL LEGISLATION OF THE COMMITTEE ON AGRICULTURE, NUTRITION, AND FORESTRY,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:40 p.m., in room SR-332, Russell Senate Office Building, Hon. Kent Conrad (chairman of the subcommittee) presiding.

Present or submitting a statement: Senators Conrad and Bond.

STATEMENT OF HON. KENT CONRAD, A U.S. SENATOR FROM NORTH DAKOTA

Senator CONRAD. This hearing before the Subcommittee on Agricultural Research and General Legislation of the Senate Committee on Agriculture, Nutrition, and Forestry will come to order.

Welcome to a hearing of the Subcommittee on Agricultural Research and General Legislation. Today we will hear from a variety of experts in agricultural research and business development. They are here to discuss the commercialization of products developed from agricultural research, and more specifically, a bill that I have introduced, along with several of my colleagues, S. 2413, the Agricultural Research Commercialization Act of 1988.

I will include my full statement in the record.

[The prepared statement of Senator Conrad follows:]

PREPARED STATEMENT OF HON. KENT CONRAD, A U.S. SENATOR FROM NORTH DAKOTA

CHAIRMAN, SUBCOMMITTEE ON AGRICULTURAL RESEARCH AND GENERAL LEGISLATION OF THE COMMITTEE ON AGRICULTURE, NUTRITION, AND FORESTRY, U.S. SENATE—HEARING: AGRICULTURAL RESEARCH COMMERCIALIZATION ACT OF 1988

JUNE 6, 1988

Welcome to a hearing of the Subcommittee on Agricultural Research and General Legislation. Today we will hear from a variety of experts in agricultural research and business development. They are here to discuss the commercialization of products developed from agricultural research, and more specifically, a bill that I have introduced, S. 2413, the Agricultural Research Commercialization Act of 1988.

Before we begin, I would like to make a few comments on the importance to the economic revitalization of North Dakota and other agricultural states of commercializing alternative agricultural products.

We are all aware of the hardships which the agricultural recession has worked on the rural areas of this country. Even in 1987 when net farm income finally rose to the average for the decade of the 1980s, grain farmers' receipts from the market (including CCC loans) were at a 25-year low. Only massive government spending kept farm income at a reasonable level.

In my home state of North Dakota, nearly two-thirds of the counties have lost population since 1980, and half have suffered from little growth or actual losses in per capita income. In both population and per capita income, rural counties and states have fared poorly relative to our urban friends.

Poverty in nonmetropolitan areas of the country is 50 percent higher than in metropolitan areas. With only 23 percent of the nation's population, nonmetropolitan areas have 30 percent of the nation's poverty. Rural (nonmetropolitan) income is 27 percent below the national average.

Unfortunately, rural revitalization is neither simple or costless. We have to begin planning, building, and investing now to stimulate rural economic growth. But, in spite of our many problems, rural America has many resources and a bright future if we put those resources to work intelligently and diligently.

What are those resources? First, we have some of the finest public and private research scientists and facilities in the world, who have been and continue to be extremely creative and innovative in basic science and in developing new uses, alternative uses, for agricultural crops and forestry products. Unfortunately, we often fail to commercialize those new products.

Second, this nation has an unsurpassed ability to produce renewable resources; more than 80 million acres of highly productive land is now standing idle—over 50 million acres in mandatory set-asides because we cannot find a market for their output. We have a vast infrastructure of roads, highways, railways, and waterways needed to move products to market. We have a skilled corps of farmers ready and willing to produce more and thousands of small businessmen and women willing to supply our farmers with agricultural inputs and services.

Finally, this nation has the entrepreneurs and risk takers willing to accept challenges.

Redeveloping our rural economies and developing new markets for our agricultural output will be one of our greatest challenges. But all of the basic resources are available, only a little coordinated effort is needed. I believe that an effective rural development policy must make the most effective use of our resources. We must depend upon ourselves to redevelop the rural economy.

After hearing the report of the Task Force on New Uses for Farm and Forest Products last year, and working carefully with a number of experts, I have introduced the Agricultural Research Commercialization Act of 1988 (ARC) along with Senators Adams, Bond, Burdick, Daschle, Fowler, Glenn, Harkin, Kennedy, and Pryor.

While the Agricultural Commercialization Act of 1988 will undoubtedly undergo some changes as it is enacted into law, its basic goal to redevelop our rural economy will not change. ARC is, I believe, a critical element in any successful and comprehensive long-term rural development policy.

Before we start, I would like to briefly outline S. 2413. My bill would establish a nonprofit corporation within USDA called the Agricultural Research Commercialization Corporation. ARCC would provide bridge financing and technical assistance to entrepreneurs to commercialize new industrial products and processes derived from agricultural and forestry products.

ARCC would establish a vital partnership between government, universities and private businesses targeted to overcome the obstacles to successful commercialization. This partnership will coordinate the efforts of all the individuals involved in moving agricultural product ideas into the marketplace, including scientists and researchers, businessmen, entrepreneurs, financiers, engineers, market analysts, and farmers.

ARCC is a jobs bill. It will create jobs in every employment sector in rural areas, from manufacturing and business management, to agricultural businesses, farming and community development. It will provide jobs to keep our young people from moving away, to keep our rural businesses from closing, and to keep our farmers on the farm. It will provide economic revitalization to rural America.

Senator CONRAD. We have had a vote set for approximately 3 o'clock, and in the interest of time and the witnesses that have come here, I will forgo my complete opening statement so that we have a chance to hear from those witnesses, hopefully before the vote is called.

We have a full hearing today with a number of panels, and so I would ask each of the witnesses to summarize their prepared statement. As always, we will include the full statement in the record, and we will also hold the record open so that there is time to answer additional questions that people might have.

So without any further delay, we will hear from Mr. Robert Long, the Deputy Assistant Secretary for Science and Education of USDA, and also Mr. Paul O'Connell, the Office of Critical Materials from USDA. First we will hear from Mr. Long. Please proceed.

STATEMENT OF ROBERT W. LONG, DEPUTY ASSISTANT SECRETARY FOR SCIENCE AND EDUCATION, U.S. DEPARTMENT OF AGRICULTURE

Mr. LONG. Thank you, Mr. Chairman. My statement is relatively brief. I do not want to cover it all and it will not take long.

I do welcome the opportunity to appear before this subcommittee to testify on S. 2413 which, as you know well, is the Agricultural Commercialization Act of 1988. There has been a great deal of interest in the Congress, and in the U.S. Department of Agriculture in the development of new uses of agricultural and forestry products, principally in the area of industrial materials.

At the present time, the U.S. Department of Agriculture is deeply involved in research and development on a variety of new crops and new products, such as kenaf, crambe, rapeseed, cuphea, and guayule under existing authority.

In 1984, USDA sponsored a public forum on "New Uses for Farm and Forest Products." A task force was also created to examine the issue of finding new uses for farm and forest products. That task force, comprised of private sector, university, and Federal members, issued a final report, with a series of recommendations to the Secretary in June 1987. The report concluded, and I quote:

> Diversification of agriculture and forestry into new products including both new crops and new uses for existing ones, is a vital national need. Indeed, the group concluded that diversification appears to offer the only response to the challenges at hand which promise to enable both revitalization of ailing segments of the industries, and full realization of the great economic potential which agriculture and forestry holds for the Nation.

While we recognize the need for development of new uses for farm and forest products, we are, in fact, carrying out such a program, the administration must be opposed to the enactment of the S. 2413.

Many of the features of S. 2413 follow the recommendations of the task force. For example, this bill authorizes the Secretary to create a $1 billion trust fund to finance an independent development corporation, and then authorizes the appropriation of "such sums as may be necessary in each of the fiscal years 1989 through 1999 to carry out the purposes of this act." If implemented to its full extent, this bill would potentially cost of tens of millions of dollars each year. Given the needs for scarce Federal resources, these costs, in our view, are excessive.

Therefore, no new legislation is truly necessary. Moreover, S. 2413 would establish an elaborate and expensive bureaucracy for Federal intervention in the development and commercialization of new products, in a manner that far exceeds the administration's view of the appropriate Federal role in such activities.

The Corporation which would be established by this bill would have authority to make agreements and contracts, to make use of

Government facilities and services, and to establish at least 10 regional centers. The Secretary would have little, if any, authority to review the decisions made by the corporation.

The Board of Directors would have the authority to make loans and grants. Again, the Secretary would have no authority to review the actions of the board with regard to loans or grants. S. 2413 makes no provision for even minimum consultation between the independent board and the Secretary. This is really unacceptable to the administration.

USDA presently has authority to enter into agreements and contracts, and to make grants, with all such transactions being subject to oversight by the Secretary. I should also note that USDA has sufficient authority to conduct research into the development of new uses for farm and forest products, through both USDA laboratories and those operated by colleges and universities. The Agricultural Research Service will support over $53 million in research on new uses of new crops during 1988, and the Cooperative State Research Service and the Forest Service also have significant efforts under way in this area. Much of the ARS work is conducted at the agency's four regional utilization laboratories which would be duplicated by the Centers authorized under S. 2413.

S. 2413 is an expensive and unnecessary piece of legislation. While the task force made many of the recommendations contained in this bill, we respectfully have rejected the idea of expending more than $1 billion dollars of taxpayers' money on an independent, unsupervised corporation. Existing authorities are adequate to address the need for research and development of new products. Paul O'Connell will review for the subcommittee the Department's activities in this area under current law.

Mr. Chairman, let me reiterate the point that the administration strongly supports the development of new uses for farm and forest products. We must, however, strongly oppose S. 2413 for the reasons I have stated here. And I would welcome the opportunity to respond to any of your questions.

[The prepared statement of Mr. Long follows:]

Statement by Robert W. Long
Deputy Assistant Secretary, Science and Education
United States Department of Agriculture
Before the
Subcommittee on Agricultural Research, and General Legislation
Committee on Agriculture, Nutrition and Forestry
United States Senate
June 6, 1988

Mr. Chairman, I welcome the opportunity to appear today before this Subcommittee to testify on S.2413, the "Agricultural Commercialization Act of 1988." There has been a great deal of interest in the Congress, and in the U.S. Department of Agriculture in the development of new uses of agricultural and forestry products, principally in the area of industrial materials.

At the present time, the U.S. Department of Agriculture is deeply involved in research and development on a variety of new crops and new products, such as kenaf, crambe, rapeseed, cuphea, and guayule under existing authority.

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"Diversification of agriculture and forestry into new products including both new crops and new uses for existing ones, is a vital national need. Indeed, the group concluded that diversification appears to offer the only response to the challenges at hand which promise to enable both revitalization of ailing segments of the industries, and full realization of the great economic potential which agriculture and forestry holds for the Nation."

While we recognize the need for development of new uses for farm and forest products, and are in fact carrying out such a program, the Administration is vigorously opposed to the enactment of S. 2413.

Many of the features of S. 2413 follow the recommendations of the task force. For example, this bill authorizes the Secretary to create a billion dollar trust fund to finance an independent development corporation, and then authorizes the appropriation of "such sums as may be necessary in each of the fiscal years 1989 through 1999 to carry out the purposes of this Act." If implemented to its full extent, this bill would potentially cost tens of million of dollars each year. Given the needs for scarce Federal resources, these costs are excessive.

Therefore, no new legislation is necessary. Moreover, S.2413 would establish an elaborate and expensive bureaucracy for Federal intervention in the development and commercialization of new products, in a manner that far exceeds the Administration's view of the appropriate Federal role in such activities.

The corporation which would be established by this bill would have authority to make agreements and contracts, to make use of government facilities and services, and to establish at least 10 regional centers. The Secretary would have little, if any, authority to review the decisions made by the corporation.

The Board of Directors would have the authority to make loans and grants. Again, the Secretary would have no authority to review the actions of the board with regard to loans or grants. S. 2413 makes no provision for even mimimum consultation between the independent board and the Secretary. This is totally unacceptable to the Administration.

USDA presently has authority to enter into agreements and contracts, and to make grants, with all such transactions being subject to oversight by the Secretary. I should also note that USDA has sufficient authority to conduct research into the development of new uses for farm and forest products, through both USDA laboratories and those operated by colleges and universities. The Agricultural Research Service will support over $53 million in research on new uses and new crops during 1988, and the Cooperative State Research Service and the Forest Service also have significant efforts under way in this area. Much of the ARS work is conducted at the agency's four regional utilization laboratories which would be duplicated by the centers authorized under S. 2413.

S. 2413 is an expensive, cumbersome, and unnecessary piece of legislation. While the task force made many of the recommendations contained in this bill, we respectfully have rejected the idea of expending more than a billion dollars of taxpayers' money on an independent, unsupervised corporation. Existing authorities are adequate to address the need for research and development of new products. Paul O'Connell will review for the committee the Department's activities in this area under current law.

Mr. Chairman, let me reiterate the point that the Administration strongly supports the development of new uses for farm and forest products. We must, however, strongly oppose S. 2413 for the reasons I have stated here.

The bill would also invite abuse and waste of taxpayers' money, and would create unintended incentives by forgiving loans to projects that fail while requiring successful projects to repay them.

I welcome the opportunity to respond to your questions.

Senator CONRAD. Let me make sure I understand you correctly. You are strongly supporting the bill, then?

Mr. LONG. If that is what I said, then we need to go back over what I said.

Senator CONRAD. That is the way I take it. We welcome your support. I must say I am a little confused by your conclusion. It seems to me basically you have set up a strawman. You keep talking about $1 billion. There is not $1 billion here.

There is $100 million. So it seems to me you have kind of set up a strawman. It was your task force that recommended the $1 billion. And it was your task force that identified the critical problem that we face in our research in agricultural sectors as being one of an inability to get our products to the marketplace.

It was your task force that identified these problems. It was your task force that said this is the kind of change that we need. And it was your task force that said $1 billion. Are you rejecting all of the task force recommendations?

Mr. LONG. No, we are not rejecting all of them.

Senator CONRAD. Which ones do you accept?

Mr. LONG. Well, the $1 billion level trust fund which they did recommend, we did not accept at the beginning.

Senator CONRAD. Do you accept any level?

Mr. LONG. Well, I do not know that we have discussed with them, or with anyone, other levels.

Senator CONRAD. That is what we are here to do today. Would you accept some other level? You have rejected $1 billion. You have rejected $100 million. Is there any level that you think is warranted?

Mr. LONG. We do have a problem, Mr. Chairman, with the Corporation idea that is totally independent of the Department.

Senator CONRAD. That was again your task force's recommendation.

Mr. LONG. We recognize that that is the case. But we do not feel that that is a functionally effective way to go about carrying out the needs in this area, and we are not saying there are not needs to transfer the technology from our laboratories into the commercial world as rapidly and effectively as we can.

We do think, and probably Dr. O'Connell's testimony will help to emphasize what, in fact, is being done, and at a relatively modest cost, and we would like to keep them in that area, not because we feel we have met all the need for the research that is necessary in these areas, but we do have an effective amount at this point in time.

And it is very difficult for us in our times to accept the concept of $1 billion even though I realize that may be pocket change around this town. It is just simply not possible.

Senator CONRAD. Well, we have rejected it. In this bill, $1 billion is not the authorization level. It is $100 million.

Mr. LONG. Income from the $1 billion that would be set up in some form of reserve?

Senator CONRAD. Well, this bill calls for $100 million appropriation. Now the question that I still want to go back to is that you have rejected, as near as I can tell, all of the substantive recommendations of your own task force. Why create a task force if, when it comes back to you and says, look, we have examined the waterfront, and we have concluded that the problem that we have is that we do not do a good job of commercializing the basic research of our country, you reject its recommendations?

Your task force comes back with specific recommendations, frankly far more ambitious than what we have called for in this bill. We have adopted the recommendations of your task force, and yet you come before us today and you say no to the $1 billion which was what your task force recommended as the authorization level; no to the $100 million, which is what we are calling for; no to anything that is independent of the Department even though that is what your task force calls for; and no, near as I can tell, to the sum and substance of what the task force came back with.

Mr. LONG. Well, that maybe indicates the fact that it was an independent task force. We did ask them to proceed on their own and determine what they felt was right. All we are saying is that we do not disagree necessarily with the need. We do disagree with the amounts that are involved. We do disagree with the mechanisms which they have recommended.

But that is our privilege to do, just as it was their privilege to go ahead and recommend as they saw it. I do not think we are really here to denigrate or put down the task force members. It was a very able group of people, and we respect them.

The fact that we could not agree is probably unfortunate, but in fact, I tried to lay out in my testimony basically the reasons why we could not.

Senator CONRAD. Well, again, your task force—it was not Congress' task force—your task force identified the problems that we face in this country with commercializing basic research. They came back, after I think a very professional review—would you agree with that?

Mr. LONG. I think they did an excellent job, very thorough job, yes. I was able to participate with them on review basis from time to time during the process as did others. But at no point did we try to say you have to do it this way, you have to do it that way. You come up with your own ideas and your thoughts, and we will go from there.

Senator CONRAD. And that is what they did.

Mr. LONG. Yes.

Senator CONRAD. And as I hear you saying it, you think they did a professional job. I do as well. That is why we offered this bill, and we recognize that $1 billion is not possible. We have a provision in the bill to authorize the establishment of a trust fund at $1 billion, from which the interest earned is used to fund ARCC. That is not mandatory. It is an option to a straight appropriation.

What we have indicated here on the Hill is clearly that $1 billion is simply not possible in this economic environment. But we would like to see a start, and we are ready to consider a different number. We have talked about $100 million because clearly $1 billion is not in the cards.

We have talked about $100 million. Would you be supportive at that level?

Mr. LONG. Let me say this, Mr. Chairman, if I can, and again, Dr. O'Connell probably can do even more of an effective job, certainly than I can. But we are underway with, and I have noted several different developments in my testimony, and he has much more detail than I do, is that we have used the principle of taking a few Federal dollars and leveraging those dollars into a much more meaningful amount.

And that has happened. And our idea and our feeling as we see it at the present time is that we would like to be in the position where we can use what we would call seed money to kind of get the wheels rolling and also stay with it longer than we ever did before, to help it get over the point of introduction into the commercial world, which sometimes our private sector is not willing to do unless we can give them a certain amount of specificity and so forth.

Senator CONRAD. Well, yes, I understand that. That is precisely why we have this bill before us. And that is precisely, I presume, why the task force recommended it. But that does not answer the question.

Would you support $100 million? You will not support $1 billion. I have not called for $1 billion. Would you support $100 million?

Mr. LONG. Well, I personally would not because I do not really think we could wisely spend it in the times ahead.

Senator CONRAD. Would you support $50 million?

Mr. LONG. I do not think I can really get into the game of what level. Now what we have not done, and at some point we need to, is to come back and say, well, we could support *x* whatever that should be, Mr. Chairman. I do not know what that level is.

If I had greater depth of background in terms of this specific area of activity, I might be able to respond more adequately. But I would rather not try to conjure up a figure that I could not support later on, for example.

But we can obviously take another look, and if that is what you want us to do, we will take another look.

Senator CONRAD. I do. And I am not hung up on any precise number. I am interested in implementing the work of your task force which I think did a very professional job. And I think honestly they identified a problem that we really have.

Do you agree that we have got a problem of not doing a good job—I do not mean that pejoratively—of not capturing the full opportunity we have with the basic research that we have done?

Mr. LONG. Yes, I agree. That has been a problem for years and years. It still is.

Senator CONRAD. Yes.

Mr. LONG. We may be doing better today than we have done in the past. That does not mean that we are doing everything that we should be doing, Mr. Chairman.

Senator CONRAD. Let me come at this point a little different way with you. The task force has also made a very clear recommendation that this be an independent entity. I hear you saying the Secretary does not want it to be independent, and I can understand that. If I were the Secretary, perhaps I would feel that way.

But this task force, which, again, not my task force, your task force, says this entity ought to be independent, ought to be outside the bureaucracy. In fact, it limits bureaucratic costs to 5 percent.

Are you saying that you reject that specific recommendation of the task force?

Mr. LONG. The task force itself was independent. Their recommendation in regard to the separate corporation we do reject, yes.

Senator CONRAD. All right. Could you give us your rationale on that point?

Mr. LONG. It is very important, I think, in terms of expenditure of Federal funds that the Department in the executive branch that has the authority to supervise and generally manage those funds cannot really give that up to a totally independent body in our view.

We think that there has to be a continuing responsibility of the Secretary of Agriculture in anything we are talking about in these terms, fairly substantial amount of money, whatever it might be. And so we do not agree with that.

We do think, as I mentioned in my testimony, this could possibly create another level of bureaucracy which we certainly do not want and need. We do not really see that it could be more effective necessarily in that kind of status.

Senator CONRAD. Do you support your administration's efforts to privatize in other areas?

Mr. LONG. Yes, in a generic sense I can say yes to that where it is possible to do.

Senator CONRAD. But you do not support any privatization moves when it comes to commercialization of basic research?

Mr. LONG. I cannot really see where that particular need—the need exists—would be furthered by this approach, this corporation.

Senator CONRAD. But the task force, your task force, thought it would be.

Mr. LONG. Well, they did obviously, and that was one of their recommendations.

Senator CONRAD. All right. I would be very interested if you would take another look at this. As I hear you, you agree that there is a need to improve the commercialization of the research that we do.

Mr. LONG. I think it needs to be strengthened, yes. It is a difficult area, and I do not mean to put down efforts in the past. It is not an easy area to accomplish effectively. And I think that our critical materials group, and those that have been working on this in relatively recent years have been very effective in getting commercialization processes underway. And it does take promotion.

Senator CONRAD. Yes. I am not interested in putting down past efforts at all. The reason, I assume, the task force came up with the recommendation they did is because we have spent billions of dollars on research and we have done very little in the commercialization area.

That is not to fault anything that has gone before. I have no interest in pointing fingers at what has gone on before. This task force, your task force, which I think did a very professional job, comes forward and says, look, we need to improve in this area.

And I think they make a powerful case. And then the question is how do you improve? As near as I can tell, you have rejected most of their substantive proposals. I find that disappointing. I think that if, in fact, they have identified a need, which I believe they have done, then we ought to be figuring out together some way to fill that gap.

I am not hung up for one minute on how that is done. I am interested in pursuing the recommendations of the task force that you all put together because I think they did a very good job of identifying a problem we have in American agriculture today.

Mr. LONG. I do not find any real disagreement with what you have to say, Mr. Chairman. We think they did a good job as well, and there is a distinct need there, and a greater effort involved than we now have. It is a matter of degree, I guess.

Senator CONRAD. Yes. One other point I want to make to you is that the Secretary appoints the Board of Directors here. So this is not an entity that operates out there without any tether. I mean this is a Board of Directors appointed by the Secretary. And I understand the reluctance of any bureaucracy to support the creation of an independent entity, and I do not use the term "bureaucracy" pejoratively. I have served as somebody in public service, and I respect what you do.

I recognize that there is a reluctance to have something that has more independence. But again, in an effort to capture the recommendations of the group that was put together by the Secretary, we have followed the outline that they proposed.

Mr. LONG. Yes, we appreciate that.

Senator CONRAD. Well, I would urge you to go back, take a look, let us know if there is a number you can support. We are not hung up on the number of Centers. We are not hung up on the dollar amount. We are very interested in implementing the basic idea that your task force came forward with. And we would like to work together to the extent possible.

Next we will hear from Paul O'Connell, the Deputy Administrator of Cooperative State Research Service of USDA. Welcome.

STATEMENT OF PAUL F. O'CONNELL, DEPUTY ADMINISTRATOR, COOPERATIVE STATE RESEARCH SERVICE, U.S. DEPARTMENT OF AGRICULTURE

Mr. O'CONNELL. Thank you, Mr. Chairman. I am pleased to be here. I appreciate the opportunity to appear before this subcommittee today to discuss S. 2413 and the ongoing activities of the U.S. Department of Agriculture related to development of new uses for farm and forest products. As the Deputy Administrator for USDA's Cooperative State Research Service, my office, in cooperation with the Agricultural Research Service, the Nation's land-grant colleges and universities, other Federal agencies, and the private sector, is directly involved in a number of research and development projects designed to bring about new and innovative uses, particularly industrial and nonfood uses, of American agricultural products.

With regard to S. 2413, I share the view of the Deputy Assistant Secretary that the legislation is not necessary in that USDA has sufficient authorities to carry out its research and development program for new crops and new products. Moreover, S. 2413 presents a unique problem of creating an independent entity which would not be required to report to, or coordinate its activities with USDA. Finally, this bill is unnecessarily expensive and obtrusive with responsibilities that are more appropriately placed in the private sector. For all these reasons, the Department is strongly opposed to the enactment of S. 2413.

In discussing research and development, which is what I would like to turn to now, it is estimated that 90 percent of the cost of R&D is development. Development is a broad term covering many diverse activities in demonstrating the usefulness of a promising technology. Some of these activities include growing and harvesting technology, raw materials handling systems, processing and extraction technology, market identification and promotion, a business plan, and formation of grower cooperatives and associations. The purpose of development is two-fold: to prepare the farm sector to grow and sell a material for a new use and to prepare industry to buy, process, and market the products. And it is this latter one as we have been discussing that we need to give more emphasis to.

In recent years, the Special Projects Unit in the Cooperative State Research Service, where I am located, has been using existing authority to bridge the gap between research results and commercialization with demonstration projects. These projects are short term, usually 3 to 5 years, with public/private partnerships established with USDA cooperative agreements. Capitalizing on decades of research done in the public sector—generally by the Agricultural Research Service or State Agricultural Experiment Stations—the demonstration projects are designed to build, within the private sector, an infrastructure that will initiate and sustain new agro-industries.

What I would like to do now, Mr. Chairman, is just briefly go through the experience that we have had with kenaf because I think it demonstrates the sort of thing that we are doing in other areas.

Kenaf provides an alternative raw material source for newsprint. Kenaf is an annual, nonwood fiber crop that will grow from seedling to 10 feet in less than 5 months, and can be transformed from seedling to newsprint in less than 7 months. The growing area is across the Southern tier of the United States. Newsprint is normally made from wood such as northern spruce and southern pine. The United States imports about 60 percent of its newsprint supply from Canada at an annual cost of $3 billion.

The Kenaf Demonstration Project began in 1986 with a cooperative agreement between USDA and Kenaf International—a venture capital firm and the product champion for kenaf. This agreement marked the reopening of research and development for kenaf in USDA after an 8-year hiatus. The project is a public/private partnership with the principal objective of gaining acceptance for kenaf as a source fiber for the manufacture of newsprint. To accomplish this objective, a Kenaf Task Force was established involving participation of a venture capital company, private laboratories, processing and pulping plants, equipment manufacturers, and the American Newspaper Publisher's Association—a prime mover in the search for a substitute newsprint fiber. This is an important concept in any of these commercialization activities of bringing together the key sectors that are going to be involved.

Under the direction of the Kenaf Task Force, kenaf has been brought into the third of a three phase program for commercialization. The first phase was a systems approach to affirm the feasibility of agricultural fiber production to newsprint manufacture on a high-speed research machine. The second phase was a scale-up for an extended run on a commercial newsprint machine and pressroom runs and analyses by major newspaper publishers. The recently begun third phase will coordinate traditional research, education, and extension resources in support of the project and the mill planned for South Texas. In other words, that is the sort of phase we move into with any of our major commodities as they get accepted in the marketplace.

The completion of the second phase demonstrated that kenaf was out of the trial stage and ready to take its place as a newsprint finish. Initial results showed that kenaf has distinct price and quality advantages, for example, uses less ink, is stronger, results in whiter paper, and requires less energy for processing.

The private sector responded with an announcement by Kenaf International and CIP Forest Products, Inc. to build a $300 million kenaf newsprint mill in South Texas for operation in 1990–91. The anticipated acreage needed to fill the mill's annual needs is 40,000 acres of unsubsidized kenaf.

The one mill for South Texas is likely just the beginning. The newsprint industry estimates that it will need 19 new mills of similar size by the year 2010 to meet estimated demand. If one-half of these were kenaf mills, U.S. farmers would have a market for 375,000 acres of kenaf.

Other technology demonstration projects currently under way are hybrid-striped bass, which is in the aquaculture area and being managed in a similar way; guayule natural rubber program in the Southwestern United States—being done cooperatively with the Defense Department; crambe-rapeseed project in the Midwest. The purpose of all these efforts is to broaden the market base for U.S. farmers.

I am pleased to have had the opportunity to discuss these few examples, and I would be glad to answer questions.

[The prepared statement of Mr. O'Connell follows:]

Statement by Paul F. O'Connell, Deputy Administrator,
Cooperative State Research Service,
United States Department of Agriculture,
Before the Subcommittee on Agricultural Research and General Legislation
Committee on Agriculture, Nutrition, and Forestry
United States Senate
June 6, 1988

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It is estimated that 90 percent of the cost of research and development is development. Development is a broad term covering many diverse activities in demonstrating the usefulness of a promising technology. Some of these activities include growing and harvesting technology, raw materials handling systems, processing and extraction technology, market identification and promotion, business plan, and formation of grower cooperatives and associations. The purpose of development is two-fold: to prepare the farm sector to grow and sell a material for a new use and to prepare industry to buy, process, and market the products. It is these efforts which S. 2413 addresses.

In recent years the "Special Projects Unit" in the Cooperative State Research Service has been using existing authority to bridge the gap between research results and commercialization with demonstration projects. These projects are short term, usually 3 to 5 years, with public/private partnerships established with USDA cooperative agreements. Capitalizing on decades of research done in the public sector -- generally by the Agricultural Research Service or State Agricultural Experiment Stations -- the demonstration projects are designed to build, within the private sector, an infrastructure that will initiate and sustain new agro-industries. One promising project involves kenaf, which can provide an alternative raw material source for newsprint. Kenaf is an annual, non-wood fiber crop that will grow from seedling to ten feet in less than five months and can be transformed from seedling to newsprint in less than seven months. The growing area is across the southern tier of the United States. Newsprint is normally made from wood such as northern spruce and southern pine. The United States imports about 60.0 percent of its newsprint supply from Canada at an annual cost of $3 billion.

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Other technology demonstration projects currently under way are a Hybrid-Striped Bass project on Maryland's eastern shore; Guayule natural rubber program in the Southwestern U.S. -- being done cooperatively with the Defense Department; and Crambe/Rapeseed project in the Midwest. The purpose of all these efforts is to broaden the market base for U.S. farmers.

I am pleased to have had this opportunity to provide you with a few examples of the present activities of USDA with regard to development of new farm and forest products.

I will be pleased to respond to your questions.

Senator CONRAD. Thank you very much for your testimony. You know the thing that I find troubling, I guess, is that the administration specifically set up this task force and was involved in the work of the task force. Of the task force members and sponsoring organizations, three were USDA representatives: Donald Nelson of the Extension Service; Jane Ross, Grants and Program Systems, USDA; and Eldon Ross, who is head of Forest Service.

Do you know how they voted on the recommendation of this task force?

Mr. O'CONNELL. Well, I was very much involved also in the task force as it went about doing its work, and we made a point when they were developing their recommendations that it be the responsibility of this group—of course, it was chaired by Ron Sampson from Procter & Gamble Co.—but that any of the policy aspects of it, as Deputy Secretary Bob Long indicated, the private members were the ones that made the choices on those. We made an effort, the USDA people, to provide the background, the technical information, and indicate what was going on.

It was the private sector people on the task force that made the recommendations.

Senator CONRAD. And the private sector people are people like———

Mr. O'CONNELL. And it is also from academia, too.

Senator CONRAD [continuing]. The head of Procter & Gamble Co. a man from the Department of Commerce; a Farmland Industries representative; representatives from Foster Wheeler, National Corn Growers, and Monsanto; the head of the department of agricultural economics, University of Missouri; Mr. Andreas of Archer Daniels Midland; and a representative of the National Grange.

What I find troubling is that you people fully participated in this, did you not?

Mr. O'CONNELL. Yes, we did.

Mr. LONG. But importantly, not in their decisions in terms of what the recommendations were.

Senator CONRAD. Yes, but you set it up. These are your appointees.

Mr. O'CONNELL. Yes, but as Bob Long had indicated in his testimony, we wanted this to be their recommendations, and we did not want to influence it because that is why we set it up. We wanted to get their recommendations on how they felt it should be accomplished.

Senator CONRAD. But then you reject all the recommendations that they made.

Mr. O'CONNELL. Well, no, I would like to comment on a point that Bob Long had made earlier, and I feel very strong about this, and it relates to the resources, not the separate Corporation. We have about four or five projects underway now, and one of the really key aspects of this is, before we go into them, we study it fairly carefully. We work with the people for some time, and this is before I came onboard, Dick Wheaton and the other ones that were involved have been working with these people for some time.

And we see what the opportunities are, and then as it comes along, we have been able to work with people with ARS and land-grant universities, some people in the private sector, and we see what kind of a mix of resources would do the job.

For example, with kenaf, it was a relatively small amount of money. We put in about $300,000 in each of 2 to 3 years to make this happen, and for this total project that I reviewed on kenaf we put in about $800,000, and the private sector put in about $1.2 million.

With regard to crambe/rapeseed, which is another one that we are working on right now, we put in about $200,000 or $300,000 last year. We put the same amount in this year. I am not saying that that is exactly the right amount. What I am saying is that you need to approach each one of these rather carefully and see what amount of money it is going to take to get the thing off the ground.

And then if it really gets going, you can put more in. I guess I am concerned about——

Senator CONRAD. But that is exactly what your task force recommended.

Mr. O'CONNELL. Yes, but——

Senator CONRAD. That is exactly what this does.

Mr. O'CONNELL. But, you see, we can do that now. You see we have now with the Technology Transfer Act, which we have now in existence which gives us a lot of tools, allows us——

Senator CONRAD. Well, wait a minute. You had that before the task force.

Mr. O'CONNELL. That just came out about 1986, you see, is when that came out.

Senator CONRAD. Yes, but I mean this task force did not conclude its work——I mean we received a report last year from the task force. They knew of that when they made these recommendations.

Mr. O'CONNELL. But, see, that was in effect—by the time that had come out, that was just right in between. It was about the same time. But that was one of the major concerns of the task force because when we first met that had not been passed, the 1986 version. The earlier version was passed.

But having patent protection was a major concern of the private sector individuals that were on the task force. The point I am trying to make is that what I think we need to be careful about, and as Bob indicated, we will go back and look at what is a reasonable amount to consider, but we can do it with a relatively small amount of resources.

And I guess we are concerned about taking Federal dollars and working with other folks and not making sure that it is being spent wisely.

Senator CONRAD. I could not agree more. But again, this is your task force. In fact, you yourself were involved in its work.

Mr. O'CONNELL. That is correct.

Senator CONRAD. If this listing is correct.

Mr. O'CONNELL. Yes, it is. No, I was very much involved.

Senator CONRAD. You were on the task force secretariat?

Mr. O'CONNELL. Yes.

Senator CONRAD. And this work came back.

Agriculture, including forestry, is a strategically vital industry for the United States. America now has an overconcentration of agricultural production in a rela-

> tively few major food and feed crops. . . . These realities pose sobering challenges to U.S. policymakers. . . .
>
> The New Farm and Forest Products Task Force was formed to respond to these challenges. . . . The task force concluded that diversification of agriculture and forestry must become a national priority. Significant opportunities exist for new farm and forest products to meet real market needs. . . .

On and on it goes. Your task force recommended setting a national goal for commercializing agricultural research and came back with a recommendation of an authorization level. We take one-tenth of what they recommended. That is what we are talking about. You do not see that in the bill because we set up the possibility of a trust fund which may be $1 billion.

But all of those who were involved here know that the specific number we are talking about is $100 million, which was the bottom-line recommendation of your task force. They said it ought to be $1 billion, but at a minimum, we ought to start with $100 million. That was your task force's recommendation.

That is what we have done here. Your task force said it ought to be an independent entity. We did not just dream this stuff up. Your task force said it ought to be independent.

Mr. O'CONNELL. If I could just comment briefly. When they were developing those recommendations, and they had, as you would expect, that had come to us and had talked with Dr. Bentley and Bob Long and others, and we did recommend to them that we did not agree with that. But we wanted them to have the independence to put in there what they felt was necessary to get the job done.

But they had asked for our comment before they put it out, and we had indicated in the two areas where Bob had indicated that we have difficulty with, we had indicated to them that we have authorities and laws to do what we have to do. And the two key things that we have, the Technology Transfer Act, and the 1985 farm bill, which allows us to use cooperative agreements with the private sector, we did not have that before the 1985 farm bill.

That has been a beautiful tool for us because it allows you to enter into a research and development project without all the constraints you have with a contract. You can enter into this arrangement, and if all the parties agree to move down the line, and if for some reason, there is a legitimate reason you cannot do something, or you can move in a new direction, we are able to do it.

So between the Technology Transfer Act and cooperative agreements and the relations we are able to have with the universities and ARS on these kind of projects, we are able to do what we need to do. Now the question about how much resources that needs to go into it, that is something that has to be studied.

Senator CONRAD. Well, they listened to that whole pitch; right? And what did they conclude?

> Specifically, the Task Force considers the establishment of an independent organizational entity, dedicated to achievement of the diversification goal and provided with adequate resources to attain it, is essential for success.

And that is their highlighting.

So they listened to that whole pitch, and they made a different conclusion—not my group, your group. All I would say to you is when you form a task force, a task force as distinguished as this one, and you fully participate in its work, not the final decision on policy matters, but in its work, I would just urge you to listen when they come back with a recommendation to you that is so clear and I think compelling.

Mr. LONG. Mr. Chairman, if I could just make a comment?

Senator CONRAD. Yes, sir.

Mr. LONG. We participated, I think, more in helping them collect information they needed to have. There is a lot of informational resource patterns that they were not familiar with. A lot of the work Dr. O'Connell and others did in support was the support for the information they needed to have. And you have repeated several times, and I hear you clearly.

All I can say is that, yes, they were independent. They came up with conclusions independent of what our views may have been. It does not make them right and us wrong, or our being right and they wrong. It shows it was an independent group that came up with the best information they felt and the best recommendation.

We still obviously reserve the right, as we do here today, to disagree respectfully in terms of some of their conclusions.

Senator CONRAD. Yes. Let me just conclude this by saying they set an ambitious goal for this country. They recommended the adoption of a national goal, and that is exactly how you get things done in this world in my observation. You set a goal. They set an ambitious goal, and I applaud them for it.

Then they said they believe the proposed goal is appropriate and attainable. However, success in achieving it will require both technological and institutional innovation. And what I hear from you all is, yeah, we have a need; yeah, there is a problem; yeah, there is an opportunity; but we are not going to have any innovation and we are not going to devote any resources to it. Well, what is the point? I do not get it. I really do not.

You have a task force. You get excellent people to serve on it. You work with them. They come back with a recommendation, and you do not adopt any of it that I can see. I have not heard one thing that you have said that is supportive of the work of your own task force.

Mr. LONG. Well, I can say this that there is no question in my mind that we are doing a great deal at this time. The only question is can we do more and should we be doing more? And that would not necessarily be resolved by the concepts that were pulled together by the group, in my opinion.

I would like to see more in this area because coming from the private sector, as I do, I can buy a private concept to the extent that it can fit our Federal structure and our Federal system. I am not satisfied that in this particular situation it, in fact, does.

Senator CONRAD. Well, all I can say is I am extremely disappointed with your response. I think this is exactly what is wrong, this kind of response, honestly. I mean no new thinking.

Mr. LONG. That is not necessarily true, Mr. Chairman.

Senator CONRAD. Well, I do not hear from you a single word of new thought that has come out here except opposition to everything your own task force recommended.

Mr. LONG. Well, we regret having to be opposed to their points of view, and we also share your view that they are a capable group of people. In our set of structures, we do not feel that what they recommended would necessarily be compatible or more successful than being done through the system that we now have and the authorities that we now operate under.

We do have a lot more latitude now than we did before. We should give that a chance to work. I think it will start to produce a lot of results.

Senator **Conrad**. They had that all in front of them when they came with this recommendation.

Mr. **Long**. But no time had been allowed since they had first heard about it to know what effects it may have.

Senator **Conrad**. Well, all I can say is I am sure you made that pitch to them, and they rejected it. I tell you they came back with exciting goals for this country, exciting goals, goals that make us reach, and we are not reaching.

All I hear is no, no, go slow, get ready for the veto, you know. That is not going to cut it. That is not going to get us going where we need to be going in agriculture. I have just been home, and I tell you it is grim. It is grim on Main Street in rural America. It is grim on the farmyards in rural America, made more grim by a drought, no doubt of that.

But this is a time that calls for vision. And I do not see any of it here today. I see it in the work of your task force. I would applaud you for whatever input you made to the task force. It must have been good because they came back with something that is ambitious and exciting.

I have got to go and vote. So we will have a recess and then come back with the next panel. Thank you very much.

[Recess.]

Senator **Conrad**. This hearing before the Subcommittee on Agricultural Research and General Legislation will resume. I notice that my colleague, Senator Bond, has joined us, and if you would like to make any kind of a statement, we would be happy to accommodate you.

STATEMENT OF HON. CHRISTOPHER S. "KIT" BOND, A U.S. SENATOR FROM MISSOURI

Senator **Bond**. Well, thank you very much, Mr. Chairman. We are, as you know, very excited about your concepts, the ARCC, and other things. I am sorry that I had other commitments and was unable to be here for the previous testimony, but I think the——

Senator **Conrad**. You did not miss too much.

Senator **Bond**. OK. Well, anyhow I wanted to come in and see my favorite bag men with the cornstarch bags which I feel are just the tip of the iceberg. I have mentioned, probably too many times already in this committee, that beginning a few years ago at the University of Missouri in our Food for the 21st Century Program we have been looking at the tremendous possibilities that the commercialization of these products has, not just for better markets for farmers and better jobs in our rural areas which badly need it, but the very positive impact it can have on our environment.

My purpose in coming today was to renew once again and express my strong support for your efforts in this area and to thank the many witnesses, the people they represent, who are making great strides. Thank you, sir.

Senator **Conrad**. Well, we very much appreciate, Senator Bond, your support for this. We have tried to express to the previous witnesses that this really embodies the recommendations of the task force of USDA, which I think did an extraordinarily good job of framing the opportunity we have in front of us. There is some disagreement on the level of funding. We understand that.

We have tried to make clear that we know there is not $1 billion available. We would like to see $100 million, and if the $100 million is not available, I think we are ready to——

Senator **Bond**. We will bargain.

Senator **Conrad**. That is right. We are ready to bargain.

Senator **Bond**. Make us an offer.

Senator **Conrad**. What we are very interested in doing is making progress in this area. So let us turn to the next panel which has Dr. Stephen Gage, the vice president of the Corporation for Science and Technology, which has also served as a model for what we are trying to do here; and Mr. Michael Aube, the president of the National Association of Development Organizations, and the president of Eastern Maine Development Corporation.

We will start with Mr. Gage, and as we have indicated to others, if you would summarize your testimony, the full testimony will be included in the record. When we have completed this panel, we will have a chance for questions.

STATEMENT OF STEPHEN J. GAGE, VICE PRESIDENT, CORPORATION FOR SCIENCE AND TECHNOLOGY, STATE OF INDIANA, INDIANAPOLIS, IN

Dr. **Gage**. Good. Thank you very much, Mr. Chairman and Senator Bond. I am pleased to appear before the subcommittee to discuss the mission, structure, and operations of the Corporation for Science and Technology (CST) and to comment on certain aspects of S. 2413.

Indiana and the Corporation for Science and Technology consider it a real compliment that the CST model has been extensively used in developing this legislation. CST was established in 1982 by the Indiana General Assembly as part of an aggressive economic development effort in the State of Indiana. It was established as a 10-year, $150 million commitment. So even in one State you can have a major commitment to solving the problems and establishing a new technology base for the State.

Senator **Conrad**. $110 million over 10 years?

Dr. **Gage**. $150 million over 10 years.

Senator **Conrad**. $150 million.

Dr. **Gage**. Over the years. The Indiana legislature has appropriated now $50 million over the past 5 years, and, in fact, has appropriated in its biennial session, authorized an additional $10 million for the upcoming fiscal year.

CST, as you know is a public/private partnership. It was set up as a private, not-for-profit company outside of the State government. It is governed by a 25-member board of directors. The board of directors is appointed by the Governor of Indiana, but that is the—other than the funding, that is the only tie with the State of Indiana.

CST's mission is to identify technology-intensive products and processes and services which have high potential to contribute to Indiana's economy. Through access to the recognized universities, and businesses and industries in Indiana, CST provides technical and business assistance, and through the funding that I mentioned a minute ago, funding assistance directly to public and private organizations.

In order to keep this testimony brief, I have submitted to the committee staff copies of our annual report and our funding criterion guidelines for submitting a proposal.[1]

As I mentioned, we have received $10 million a year for the past 5 years. At this point we have made $46 million in investments in 91 projects. The investments have been made in four major categories: We have invested in new business startups; new product lines in both established and emerging companies; university research and development (R&D) Centers; and in feasibility studies.

The first two categories, new business startups and new product lines, accounts for almost 75 percent of our investments. The most common forms of awards which we make are a conditional loan to a private company, and a grant to a R&D Center. Just as important as the money, we work very closely with the companies to help arrange for any technical assistance or business assistance they need, and to help them arrange for additional capital, either through venture capital funding or through the conventional financing to help bridge the projects from the R&D stage into commercial sales.

As you requested in your letter, Mr. Chairman, we at CST have very carefully reviewed the proposed Agricultural Research Commercialization Act (S. 2413). I would say that while there are many similarities between ARCC, as described in the bill, and CST, I would like to point out a few significant differences.

In fact, I will just comment very briefly on five of these differences, and then maybe we could explore any that interest you in more detail in questions.

First, S. 2413 stipulates that the ARCC Board of Directors would consist of 25 members, of which 10 members would be the 10 regional directors and 15 would be representative of the agricultural, scientific, financial and managerial communities. As I pointed out a few minutes ago, CST's board consists of 25 "outside" directors drawn equally from business, government, and university sectors. In CST's case, none of the members of the board of directors has any administrative responsibility for CST's program. And I think that is a significant difference.

Second, S. 2413 limits the funding which can be spent on ARCC administrative expenses to 5 percent of the annual appropriations. While this may be an appropriate cap, we would suggest the subcommittee look very closely at the actual experience of similar organizations around the country before setting such a limit in law. We cannot make a direct comparison between CST's operations and those intended by this bill, in part because our annual funding is $10 million while the ARCC's proposed level would be $100 million. But we suspect that our experience does have some projective value for estimating what the reasonable administrative spending should be for ARCC. Over the last few years, CST's administrative expenses have been completely covered by interest on the nondisbursed allocated funds which we have received from the State. In other words, we do not pay them all up front immediately, but we take the money which comes from the State, invest it, and we basically live off that investment. We have not spent $1 of State appropriated moneys for the administrative costs.

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[1] Indiana Corporation for Science and Technology, a partnership of business, government and universities, "Annual Report 1987" and the third biennium edition of "Funding Criteria and Guidelines for Submitting a Proposal," are retained in the subcommittee file.

But the point that may be of direct relevance to your hearing here today is that our administrative expenses have been running about 7 to 9 percent of the amount appropriated by the State. And we operate quite frugally.

We have very little air travel. Most of it is by car. Our salary structure, I think, on the whole would be significantly less than associated with this type of organization. So we would just urge caution before you set this law to avoid handicapping a successful organization.

A third point is that with respect to proprietary rights, S. 2413 stipulates that ARCC should not receive any proprietary rights or patent rights. While we fully agree with the intent of this bill to encourage private commercialization of research results, we are afraid that this provision might actually work at cross-purposes with the intent. CST encourages private companies and universities receiving our funds to vigorously protect property rights. But we also include a provision in our contracts with both companies and universities that under certain circumstances, CST can obtain a nonexclusive license to the technology so that we, in turn, can license a technology to another company for commercialization. Without such a provision, we do not know how you would keep a company or any other entity, for that matter, from just sitting on a piece of intellectual property which could keep a product off of the market.

Fourth point, S. 2413 stipulates that successful commercialization efforts should repay the grants on a dollar-for-dollar basis. While the bill provides for the collection of interest on loans as an additional source of revenue, it does not appear to us that there would be enough financial return from ARCC's investments for the revolving fund to become self-funding, which we understand is the intent. By comparison, CST's board of directors established a policy of requiring a repayment of twice the amount of the loan. It is too early to tell, even after 5 years of experience, whether even a multiplier of 2 will be adequate to create a self-sustaining fund, but we are pretty confident of this point given a certain number of failures which are inevitable in this risky area to think that anything less than a multiple of 2 would ever lead to a possibility of a self-perpetuating fund.

The last point, with respect to the allocation of funds to the several Regional Centers, we would like to suggest that the approach envisioned by the bill will inevitably lead to imbalances in the program, that is some regions will have a surplus of worthy proposals and a deficit of funds, and vice versa. One of the things I think I should share with you is that at a minimum, this kind of imbalance will lead interested companies to shop their proposals around the country.

We find this already as companies propose to us that they would like to take our money and they would be happy to move to Indiana or at least part-time in order to get that money. So this would require at least very special coordination among the regions.

A possible alternative might be to construct an allocation formula which disburses a fraction of the funds in proportion to each region's share of gross agricultural sales and which reserves the remaining funds for disbursement by the board of directors on the basis of demonstrated need. In other words, the number of qualified, unfunded proposals, and this type of administrative discretion in the hands of the board might serve to give a balanced approach and yet one flexible enough to allow for the dealing with the kind of imbalance that would otherwise develop.

We really appreciate the opportunity to testify on this important bill, and I will be happy to answer any questions.

[The prepared statement and attached chart of Dr. Gage follows:]

STATEMENT OF STEPHEN J. GAGE, VICE PRESIDENT, CORPORATION FOR SCIENCE AND TECHNOLOGY, STATE OF INDIANA

Mr. Chairman and distinguished members of the Subcommittee, I am pleased to appear before the subcommittee to discuss the mission, structure, and operations of the Corporation for Science and Technology (CST) and to comment on certain aspects of the Agricultural Research Commercialization Act of 1988.

Indiana and the Corporation of Science and Technology consider it a genuine compliment that the CST model has been extensively used in developing the legislation now under consideration. As a critical part of Indiana's aggressive economic development efforts, the Corporation was established by the Indiana General Assembly in 1982 as a ten-year, $150 million commitment. A public-private partnership, CST was set up as a private not-for-profit company governed by a 25-member Board of Directors. The Board is comprised of senior officials from Indiana's business, government, and university sectors. CST has a full-time staff of fourteen who operate under the direction of its president, Dr. John D. Hague.

CST's mission is to identify and develop technology-intensive products, processes, and services that have high potential to contribute Indiana's economy. Through access to Indiana's world recognized universities and outstanding businesses, industries, financial institutions, and government, CST provides technical, business, and funding assistance. In order to be brief, I would like to submit copies of CST's Annual Report and Funding Criteria and Guidelines for Submitting a Proposal for the record.

CST's funding is provided by the Indiana General Assembly. For the past five years, the General Assembly has provided $10 million per year. Over the past five years, CST has invested over $46 million in 91 projects. The investments have been made in four major categories:

- o New Business Startups
- o New Product Lines in Both Established and Emerging Companies
- o University Research and Development (R&D) Centers
- o Feasibility Studies.

The allocation among these four categories, as shown in the attached chart, is roughly one-fourth in New Business Startups, one-half in New Product Lines, one-fifth in R&D Centers, and the remainder in Feasibility Studies.

Awards are based on a rigorous four-stage evaluation of the technological and business merits of the proposals which must include a detailed business plan. The most common forms of awards are: (1) a conditional loan to a private company, and (2) a grant to a R&D Center. After funding, the performance of each project is reviewed monthly by CST; needed assistance can then be provided by CST to the companies on a timely basis. In addition, CST works closely with the companies to help arrange for venture capital or conventional financing to bridge the project into commercial sales.

My brief description of CST would be incomplete if I did not indicate the critical role played by the 13 Targeted Technology Committees. With over 500 voluntary members statewide, the extensive network created by these committees keeps CST abreast of the technology developments most important for Indiana's future. Committee members assist in the review of all proposals considered by CST. They provide business and technical assistance to companies seeking help from CST. Of greater importance to the Indiana companies and educational institutions represented, though, are the vital relationships which have been established among the participants.

As you requested, Mr. Chairman, we at CST have carefully reviewed the proposed Agricultural Research Commercialization Act (S. 2413). While there are many similarities between the Agricultural Research Commercialization Corporation (ARCC) described in that bill and CST, I should also point out that there are some significant differences.

First, S. 2413 stipulates that the ARCC Board of Directors would consist of 25 members of which 10 members would be the 10 Regional Directors and 15 would be representative of the agricultural, scientific, financial, and managerial communities. As I pointed out above, CST's Board consists of 25 "outside" directors drawn equally from the business, government, and university sectors. In CST's case, the Board members independently set policy and make decisions on programs and funding; none have any administrative responsibilities for CST's operations.

Second, S. 2413 limits the funding which can be spent on ARCC administrative expenses to 5 percent of the annual appropriations. While this may be an appropriate cap, we would suggest that the Subcommittee look closely at the actual experience of similar organizations around the country before setting such a limit in law. We cannot make a direct comparison between CST's operations and those intended by this bill, in part because our annual funding is $10 million while the ARCC's proposed level would be $100 million. Over the last few years, CST's administrative expenses have been completely covered by the interest on non-disbursed allocated funds. They have been running about 7 to 9 percent of the amount appropriated. And we operate frugally.

There are undoubtedly some functions which would cost less on a per unit basis (per $1 million appropriated) at $100 million than at $10 million. On the other hand, the bill envisions a national Board of Directors meeting periodically to make policy and funding decisions for 10-12 geographically dispersed operations. The travel costs for these Board meetings, the necessary regional review meetings, and Regional Center administrative travel will be significantly higher, on a per unit basis, than at CST. By comparison, most of our travel is accomplished with one-day trips by automobile.

Third, with respect to proprietary rights, S. 2413 stipulates that ARCC shall not receive any proprietary right or patent rights. While we fully agree with the intent of this bill to encourage private commercialization of research results, we feel that this provision could actually work at cross-purposes with the intent. CST encourages private companies and universities receiving our funds to vigorously protect property rights. But we also include a provision in our contracts providing that, under certain circumstances, CST can obtain a non-exclusive license to the technology so that we could in turn license the technology to another company for commercialization. The circumstances, such as business failure or lack of interest by a university or company in pursuing commercialization, are somewhat extreme but they inevitably will be faced in such a program.

Fourth, S. 2413 stipulates that successful commercialization efforts should repay the grants on a dollar-for-dollar basis. While the bill provides for the collection of interest on loans as an additional source of revenue, it does not appear that there will be enough financial return from ARCC's investments for the Revolving Fund to become self-funding. After considering the likely effects on the companies in which CST invests, the likely success rate of those companies, and the desire to make CST self-funding in the long run, CST's Board of Directors established a policy of requiring a repayment of twice (2X's) the amount of the loan. It is too early to tell whether even a multiplier of 2 will be adequate to create a self-sustaining fund.

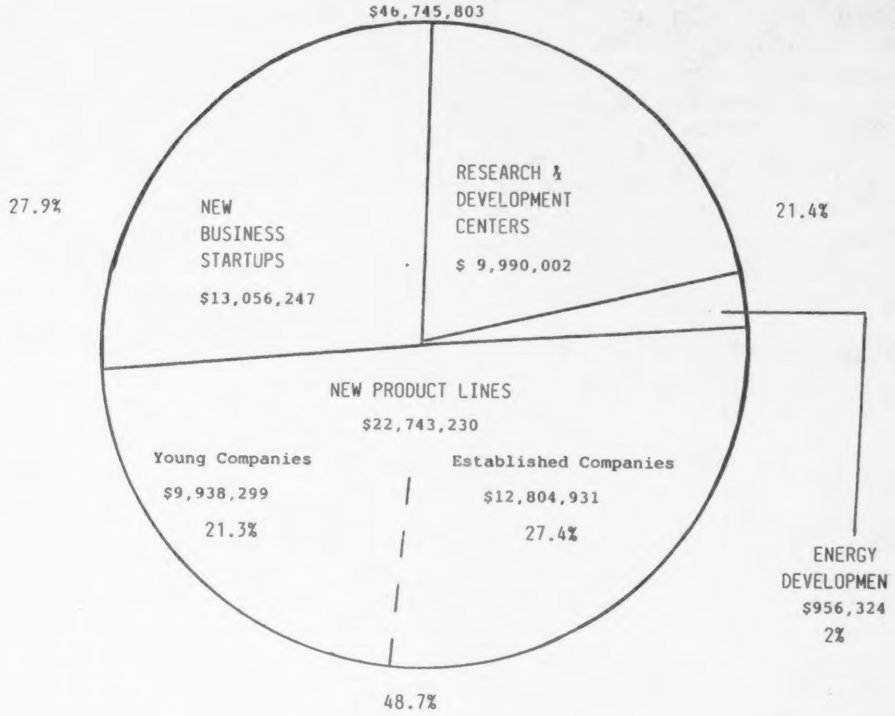
Finally, with respect to the allocation of funds to the several Regional Centers, we would like to suggest that the approach envisioned by the bill will inevitably lead to imbalances in the program, i.e., some regions will have a surplus of worthy proposals and a deficit of funds while other regions will have a surplus of funds and a deficit of fundable proposals. At a minimum, this will lead interested companies to "shop their proposals around," thus requiring at least special coordination among the regions. A possible alternative would be to construct an allocation formula which disburses a fraction of the funds in proportion to each region's share of gross agricultural sales and which reserves the remaining funds for disbursement by the Board of Directors on the basis of demonstrated need, i.e., the number of qualified, unfunded proposals.

Thank you for the opportunity to testify on this important bill. I'll be happy to answer any questions you have.

Attached chart, CST Diversified Investments, follows:

CST DIVERSIFIED INVESTMENTS

Funds Committed to Date
June 30, 1988



Senator CONRAD. I am going to change a little bit the way that I planned to proceed. My original intent was to go to Mr. Aube next, but I think it might be beneficial to stop at this point and follow up with you, Dr. Gage. Let me first say we deeply appreciate your being here today, and we very much appreciate the thought that you have put into this because we are very interested, the other cosponsors and I, with putting together something that works.

Your first suggestion, I think, makes a great deal of sense on the Board of Directors; making it fully independent. I will support an amendment, in fact, I will offer an amendment to do that because I do think that makes very good sense.

The second suggestion that you make is on the administrative expenses. Obviously we were trying to put a very strict limit and a very tough limit on the administrative expenses, and I think that is something we need to review based on what you have told us. But yet I think you can understand our desire to try to make sure the money does not get chewed up in administrative expenses in this kind of body because we very much want the money to go out to those projects that qualify.

We think this is somewhat of a different animal. A State operation obviously is a different base to operate on than we would have at a national level.

Dr. GAGE. It is cheaper, Senator. It is cheaper in the State typically.

Senator CONRAD. It probably is cheaper in the State, but we have a much bigger base, and maybe this would be a healthy thing for the Federal Government to try; limiting what it was going to do in terms of administrative overhead.

The third point on proprietary rights that you make is something that we have discussed several times, because it is one that has concerned us. I think you have made an excellent suggestion. If there is legislative language that you have that governs the operation of the CST area in this area, I would be very interested in getting that language because I think it is language that we ought to seriously consider adopting.

The fourth point on repayment on a dollar-for-dollar basis is also something we have talked about, and have already decided it has to be altered in some way. We have not figured out how to alter it. You have made a suggestion here on what is done at the CST; repayment of twice the loan amount. I find that an attractive alternative. We have also thought about having, and I would be very interested in your reaction to this, an equity position.

What is the CST's analysis or evaluation of that kind of involvement?

Dr. GAGE. The Indiana attorneys general reading of the State constitution in Indiana precludes CST from taking equity position in company. We have gone farther. We have actually rationalized that that is probably not appropriate either because then that would put us in the business of disposing of those equity interests. And as a quasi-public organization that is not the easiest thing to do.

It would set up a whole additional bureaucracy, additional costs, et cetera, which we presumably would reclaim from initial public offerings or sale of companies and the rest. But it probably puts a quasi-governmental organization into a role that is not appropriate.

So obviously one of the reasons why we have gone with the conditional loan with the 2 times payback as a means of moving toward self-funding has been conditioned by the fact that we could not take equity positions.

It does get to another point, though. We are experimenting, not only Indiana but a number of the other States, where the most exciting new, innovative programs in this area are taking place, really experimenting what is the appropriate role. I think the Federal Government should watch these experiments very closely, but we are trying to find out how far this type of an organization should get involved in market intervention in order to accelerate development of new commercial products, but at a minimum intrusion into the activities of the ongoing business.

Yet one of the things we have learned over the past 5 years is the same thing the venture capital companies will tell you at the very first meeting. That is that the three most important things in a new business are management, management, and management. And so we have been trying to discover how to use a soft hand in working with the management of the new companies and the smaller companies working on new product lines. We would think that an equity investment where we would install members of the board of directors or a president would be too heavy-handed.

But short of that, we take a very active role in working with our companies, and we have a very proprietary view of these investments, as really investments rather than grants or hands-off loans. So that is something else to think about in terms of the type of staffing and the level of staffing that you would want in these Regional Centers.

Senator CONRAD. All right. Just to comment on the final item that you mentioned, the allocation of funds, that too is an interesting suggestion. I think we will want to go back and talk about the recommendation that you have made and listen to others about that as well.

Let me ask you two other questions because I am very interested in what you have experienced in two areas. One, have you been able to attract venture capital, and if so, could you give us an idea of the kinds of successes you have had in that area?

Dr. GAGE. Several of the investments we have made have reached a point of maturity where they are going for venture capital funding. And of these, a few have been successful in attracting quite admirable amounts of venture capital. We have already started to receive payback from some of the investments.

We are at a point right now where this payback should be accelerating pretty dramatically after 5 years of investments. It is not altogether clear, though, that all of our development investments are, in fact, going to carry the product far enough along in the development process to attract conventional or venture capital financing.

We are discussing actively at this time possibly making further investments in some of these companies to provide that last bit of bridge financing, for the companies then to move into commercial sales. Our board of directors up until this point has precluded the use of CST funds for marketing and manufacturing facilitization.

We have an active review underway at this point and may well be moving toward allowing for the investment of some of the CST funds to do market research studies and further engineering studies to help the companies get to the point where they can basically take a plan into a bank and get collateral financing, based on the manufacturing.

Again, we are moving slowly, cautiously, experimentally to try to find out how far we should go.

Senator CONRAD. The final question I have is that I would guess you have had some successes and some failures. Maybe you could give us some examples of both, and maybe a little analysis on what you have seen that has allowed some to be successful and others to perhaps not be as successful as hoped.

Dr. GAGE. As the people in the venture capital community say, in every portfolio you have some pearls and you have some lemons. The lemons mature more quickly. The pearls take a long time to nurture. Yes, we have had some failures, very few, very, very few technical failures, but some early business failures.

We also, it appears, have some hopefully fairly spectacular technical and business successes. Several of our investments are in the area of medical technology, and in these cases the technology has been developed. They are in clinical trials right now, and based on, in one case, the approval by the FDA. Vaser Inc., an Indianapolis-based company, will then begin marketing a laser angioplasty catheter system, which has already received $10 million worth of venture capital funding from Allstate Venture Fund.

That is the type of thing which grabs the headlines, as you can well imagine. We have a number of other investments, a few in the agricultural area, a number in the software and computer area, a number in the area of manufacturing, technology and manufacturing software.

And then a few others. We are absolutely open to any proposal from anyone in Indiana with an idea, and I think we are at a point right now where we would say that, well, where we have at least 15 of our companies in the commercial market and many of them past the point of break-even, and are generating enough revenues, and have started the payback process to us.

Senator CONRAD. That was going to be my final question.

Dr. GAGE. I would be happy to submit a list of all of our projects.

Senator CONRAD. I would very much appreciate getting something like that.

[The material follows:]

PRINCIPAL INVESTIGATOR DIRECTORY September, 1988

PROJECT	TITLE	SUBMITTOR	PRINCIPAL INVESTIGATOR	PHONE #	ADDRESS	COUNTY	COMMITMENT
CP P-3016	Technology 2000	Indpls. Center for Advanced Research	Tim Janis, Ph.D.	(317) 262-5052	611 North Capitol Avenue, Indianapolis, IN 46204	Marion	$60,000
CP P-3017	A-Film Machining	Edge Technologies, Inc.	George A. Kim	(317) 293-2165	4455 West 82nd Street, Indianapolis, IN 46268	Marion	$750,000
CP P-3019	VLSI Design System	Purdue University/IBM	Dr. Steven C. Bass	(317) 494-3485	School of Electrical Engineering, W. Lafayette, IN 47907	Tippecanoe	$342,195
RM P-3020	Institute for Molecular & Cellular Biology	Indiana University	Dr. Rudolf A. Raff	(812) 335-4183	Jordan Hall 322A, Bloomington, IN 47402	** Monroe	$1,217,852
RM P-4005	Purdue AgriGenetics Center	Purdue University	Dr. Mark A. Hermodson	(317) 494-1636	Department of Biochemistry, West Lafayette, IN 47907	** Tippecanoe	$1,470,390
BW P-4012	Start CAD/CAM Institute	Summit Tech. & Research Transfer Ctr.	Dr. James T. Dittoe	(219) 424-1435	Chamber of Commerce, 826 Ewing St., Ft. Wayne, IN 46802	Allen	$815,166
		Indiana Univ. / Purdue U. of Fort Wayne	Dr. Warren Worthley	(219) 482-5327	2101 Coliseum Blvd. East, Ft. Wayne, IN 46805	* Allen	
RM P-4020	Technology Services Center	Indiana State University	Dr. Clois Kicklighter	(812) 237-3166	School of Technology, Terre Haute, IN 47809	Vigo	$200,000
CP P-4023	Track Pads for U. S. Army Tanks	Alphaflex Industries, Inc.	Charles Shoup	(317) 577-0551	6805 Hillsdale Court, Indianapolis, IN 46250	** Marion	$99,000
CP P-4027	Conductive Ceramic Materials	CTS Corporation	Craig Ernsberger	(219) 293-7511	905 N. West Boulevard, Elkhart, IN 46514	Elkhart	$934,359
		University of Notre Dame	Dr. Albert E. Miller	(219) 239-6277	University of Notre Dame, Notre Dame, IN 46556	* St. Joseph	
CP P-4028	Ultrasound Surgical Scanner	Indpls. Center for Advanced Research	Gary Meyer	(317) 262-5012	611 North Capitol Avenue, Indianapolis, IN 46204	Marion	$218,000 #
		LABECO	Narendra T. Sanghvi	(317) 831-2990	156 Harrison St., Mooresville, IN 46158	Morgan	
CP P-4029	Talking Portable Computer	Computer Aids Corporation	William Grimm	(219) 422-2424	124 W. Washington, Lower Arcade, Fort Wayne, IN 46802	Allen	$55,000
DS P-4030	Closed Loop Heat Transfer Systems	Stratus Corporation	Robert Oswald	(219) 234-3386	211 West Washington Street, South Bend, IN 46601	St. Joseph	$296,454
		Purdue University	Dr. David R. Tree	(317) 494-2138	Herrick Labs, Mechanical Eng., W. Lafayette, IN 47907	* Tippecanoe	
DS P-4032	Cardiorespiratory Monitor for Anesthesia	Purdue University	Dr. Joe D. Bourland	(317) 494-2995	Biomedical Engineering Center, W. Lafayette, IN 47907	** Tippecanoe	$196,020
CP P-4034	American Syn-Fuel Corporation	Stone & Webster Engineering Corporation	Ed Piper	(303) 741-7498	Feasibility study prior to site selection.	No county selected	$401,300
CP P-4035	Testing of Indiana Oil Shale	Stone & Webster Engineering Corporation	Ed Piper	(303) 741-7498	Feasibility study prior to site selection.	No county selected	$50,000
CP P-4036	Feasibility of Oil Shale Production Plant	Stone & Webster Engineering Corporation	Ed Piper	(303) 741-7498	Feasibility study prior to site selection.	No county selected	$100,000
BW P-4037	Feasibility of In-Situ Oil Production	Eastern Shale Research Corporation	Victor H. Carr	(317) 392-4842	P.O. Box 308, Shelbyville, IN 46176-0308	Shelby	$73,850
DS P-4038	Electrophoretic Sulfur Reduction In Coal	Indiana University	Dr. Jeremy Dunning	(812) 335-9485	School of Public & Environ. Affairs, Bloomington, IN 47405	Monroe	$90,466
		Indiana University	Dr. J. C. Randolph	(812) 335-9485	School of Public & Environ. Affairs, Bloomington, IN 47405	Monroe	
		Indiana University	Dr. Jeffrey White	(812) 335-9485	School of Public & Environ. Affairs, Bloomington, IN 47405	Monroe	
DS P-4044	Feasibility of 500 BPD Oil Demo Plant	Cliff's Engineering, Inc.	Gary Abo	(303) 625-2445	Feasibility study prior to site selection.	No county selected	$240,908
CP P-4054	Track Pads for Vehicles (Phase II)	Alphaflex, Industries, Inc.	Charles Shoup	(317) 577-0551	6805 Hillsdale Court, Indianapolis, IN 46250	** Marion	$90,000
RM P-4057	Products to Preserve Fresh Produce	Agra-Research, Inc.	Dr. Joe H. Cherry	(317) 463-3883	2701-C Kent Avenue, W. Lafayette, IN 47906	Tippecanoe	$288,532
RM P-4059	Software for Robot Control	Cybotech Corporation	Paul Wycoff	(317) 298-5816	P.O. Box 88514, Indianapolis, IN 46208	Marion	$1,752,000
		Purdue University	Dr. Raymond J. Cipra	(317) 494-6900	Mechanical Eng. Bld., W. Lafayette, IN 46907	* Tippecanoe	
CP P-4060	Advanced Imaging System for Cardiology	Microsonics Inc.	Roger E. Camp	(317) 841-7222	7155 Shadeland Station #190, Indpls., IN 46256	Marion	$1,017,206
		Indiana University School of Medicine	Dr. James C. Dillon,M.D.	(317) 264-3841	School of Medicine, 926 W. Michigan St., Indpls., IN 46202	* Marion	
DS P-4063	Hydraulic Multi-Spindle Nutrunner (1 & 2)	Wolverine Assembly Technologies, Inc.	Raymond F. Clements	(317) 784-4060	5456 Antonelli Ln. Beech Grove, IN 46237	Marion	$600,000
DS P-4070	Recycling Industrial Waste Materials	Indiana University	Dr. Michael O. Holowaty	(219) 980-6666	3400 Broadway, Gary, IN 46408	Lake	$92,831
CP P-4077	Porous Coatings by Laser Method	Boyd Machine & Repair Co., Inc.	Larry L. Boyd	(219) 635-2195	R.R. #1, Box 233, Kimmell, IN 46760	Noble	$180,000
DS P-4078	Sorbent Suspension Detoxifier	Ash Medical Systems, Inc.	Dr. Stephen R. Ash, M.D.	(317) 463-9540	2701-B Kent Avenue, West Lafayette, IN 47906	Tippecanoe	$96,000
DS P-4083	Personal Arrhythmia Monitor (PAM)	Purdue University	Dr. Leslie A. Geddes	(317) 494-2995	Biomedical Engineering Center, Purdue University	** Tippecanoe	$357,500
DS P-4084	Electrophoretic Teaching/Research Systems	Biostar Corporation	Jeffrey W. Brown	(317) 448-6832	P.O. Box 5756, Lafayette, IN 47903	Tippecanoe	$67,000
CP P-4091	Laser Angioplasty Catheter System	Vaser Incorporated	Michael E. Lockrone	(317) 247-8016	2431 Directors Row, Indianapolis, IN 46241	Marion	$500,000

PRINCIPAL INVESTIGATOR DIRECTORY September, 1988

PROJECT	TITLE	SUBMITTOR	PRINCIPAL INVESTIGATOR	PHONE #	ADDRESS	COUNTY	COMMITMENT
DS P-4092	Automated Mapping & Facilities Management	Encore Services, Inc.	Eric V. Goodnight	(317) 482-3045	P. O. Box 652, Lebanon, IN 46052	Boone	$602,150
		Lynsys, Inc.	Steve Van Frank	(317) 497-0399	1001 South Street, Lafayette, IN 47904	Tippecanoe	
BW P-4094	Ultrasonic Gallstone Diagnosis/Therapy	Indpls. Center for Advanced Research	Dr. Thomas Franklin	(317) 274-4500	611 North Capitol Avenue, Indianapolis, IN 46204	Marion	$1,103,000
		LABECO	Francis J. Fry	(317) 831-2990	156 Harrison St., Mooresville, IN 46158	Morgan	
RM P-4097	Applied Optics Center	Rose-Hulman Institute of Technology	Dr. Brij M. Khorana	(812) 877-8423	5500 Wabash Avenue, Terre Haute, IN 47803	Vigo	$573,009
CP P-4102	A-File Machining (Phase II)	Edge Technologies, Inc.	George A. Kim	(317) 293-2165	4405 West 82nd Street, Indianapolis, IN 46268	Marion	$1,490,300
CP P-4103	Ultrasonic Lateral Imaging	Indpls. Center for Advanced Research	Dr. Phillip Bendick	(317) 630-6704	611 North Capitol Avenue, Indianapolis, IN 46204	Marion	$60,000
BW P-5004	Video Recognition Products	BEECO, Inc.	Larry Egelhoff	(317) 547-1717	4175 Millersville Road, Indianapolis, IN 46205	Marion	$750,000
		Indiana State University	Dr. Leland B. Moore	(812) 232-6311	Dept. of Electronic & Computer Tech., Terre Haute, IN 47809	* Vigo	
DS P-5005	Software for Micro-Link Microcomputer	Micro-Link Corporation, Inc.	Dr. A. Donald Duke	(317) 846-1721	14602 North U.S. Highway 31, Carmel, IN 46032	Hamilton	$375,000
CP P-5016	Module for Residential Comfort/Hot Water	Artesian Building Systems, Inc.	Maurice A. Rice	(317) 448-4538	100 Creasy Lane, P.O. Box 6296, Lafayette, IN 47905	Tippecanoe	$671,151
CP P-5018	Audionics Speaker Boundary	Audionics, Inc.	Wayne L. Staley	(317) 654-5787	801 South Columbia Street, Frankfort, IN 46041	Clinton	$95,612
RM P-5021	Laboratory Computing Environment	Scientific Software Products, Inc.	Dr. Robert D. Hogan	(317) 293-9270	5720 West 71st Street, Indianapolis, IN 46278	Marion	$590,017
CP P-5029	Ogden Programmable Controller	Ogden Engineering Corporation	Neal Bannister	(219) 322-5252	372 W. Division St., P.O. Box 148, Schererville, IN 46375	Lake	$232,455
RM P-5030	IIventure Incubator Center	IIventure, Inc.	Dr. A. Alan B. Pritsker	(317) 463-5557	1291-H Cumberland Ave., PO Box 2378, W. Lafayette, IN 47906	** Tippecanoe	$200,000
CP P-5032	Biological Indicator Devices	Chem-Elec., Inc.	William E. Woenker	(219) 834-4080	P.O. Box 372, North Webster, IN 46555	Kosciusko	$644,831
CP P-5032R1	Test for Marijuana Use	Chem-Elec., Inc.	William E. Woenker	(219) 834-4080	P.O. Box 372, North Webster, IN 46555	Kosciusko	$53,290
DS P-5037	Low Cost Metallic Powders	Applitech of Indiana, Inc.	Dr. Nathaniel R. Quick	(317) 872-6109	8150 Zionsville Road, Indianapolis, IN 46268	Marion	$625,000
* P-5048	Indiana Microelectronics Center	Corporation for Science & Technology	CST Staff	(317) 635-3058	One N. Capitol, Suite 925, Indianapolis, IN 46204	Marion	$542,810
DS P-5049	Automated Data Acquisition/Control System	Circle Imagineering, Inc.	Carl L. Douglas	(317) 259-1202	5106 West 79th Street, Indianapolis, IN 46268	Marion	$378,277
RM P-5050	Manufacturing Scheduling System	Factrol Inc.	Dr. Hank Grant	(317) 463-3637	P.O. Box 2509, West Lafayette, IN 47906	Tippecanoe	$350,000
RM P-5058	Optoelectronics Center	Purdue University	Dr. Richard J. Schwartz	(317) 494-3536	School of Electrical Engineering, West Lafayette, IN 47907	** Tippecanoe	$2,477,659
DS P-5060	Portable, Cellular, Lapsize Computer	Remote Equipment Corporation	James E. Young	(317) 926-1933	4439 Edinburgh Point, Indianapolis, IN 46208	Marion	$764,000
DS P-5068	Optical Scattering Flowmeter	Ash Medical Systems, Inc.	Dr. Stephen R. Ash, M.D.	(317) 463-9560	2701-B Kent Avenue, West Lafayette, IN 47906	Tippecanoe	$413,100
RM P-5069	Ultrasonic & Microwave Therapy for Cancer	Laboratory Equipment Corporation	Theodore M. Englehart	(317) 831-2990	156 Harrison Street, Mooresville, IN 46158	Morgan	$826,100
RM P-5072	Diagnostic Test for Chlamydia Trachomatis	Boehringer Mannheim Diagnostics	Dr. Juergen Schrenk	(317) 576-7523	9115 Hague Road, Indianapolis, IN 46250	Marion	$316,031
		Indiana University School of Medicine	Dr. Charles E. Wilde III	(317) 274-0500	635 Barnhill Dr., Indpls., IN 46223	* Marion	
DS P-5073	Components Manufacturing Injection Molding	Components General Corporation, Inc.	Dr. Marina S. Lavin	(317) 452-2440	401 West Morgan, Kokomo, IN 47902	Howard	$801,000
RM P-6005	DIMS and CAE Software	Modern Computer Aided Engineering, Inc.	Dr. Khosrow Nematollahi	(317) 497-1550	1231 Cumberland Avenue, Suite A, West Lafayette, IN 47906	Tippecanoe	$219,050
BW P-6006	Sludge Dewatering Process	Jackman Enterprises, Inc.	Dale E. Jackman	(219) 931-5450	P.O. Box 4068, Hammond, IN 46324	Lake	$283,410
RM P-6015	Underwriting Assistant Software	PALLM, Inc.	Thomas A. Roberts	(317) 871-4700	4040 Vincennes Circle, Indianapolis, IN 46268	Marion	$920,000
RM P-6016	Latex Immunoassay Tests for Drugs/Hormones	Seradyn Diagnostics, Inc.	Dr. Andris Indriksons	(317) 226-2990	1200 Madison Avenue, Indianapolis, IN 46225	Marion	$1,500,000
CP P-6018	Solid State Test for Pollutants	Environmental Test Systems, Inc.	Dr. Robert Boguslaski	(219) 262-2060	P.O. Box 4659, Elkhart, IN 46514-0659	Elkhart	$626,200
CP P-6019	Enzyme Test for Theophylline	GDS Technology, Inc.	Dr. Aurora F. de Castro	(219) 264-7384	25235 Leer Drive, Elkhart, IN 46514	Elkhart	$387,460
CP P-6021	Turbomachinery Software	Technalysis, Inc.	Dr. Akin Ecer	(317) 291-1985	7120 Waldemar Drive, Indianapolis, IN 46268	Marion	$589,000
DS P-6027	Micropropagation of Plants	Ahrens Strawberry Nursery	Philip C. Ahrens	(812) 683-3055	R.R. #1, Huntingburg, IN 47542	Dubois	$67,350
CP P-6028	Environmental Control System Agribusiness	Sci-Agra, Inc.	G. Irving Latz, 2d	(219) 484-1267	5020 Executive Blvd., P.O. Box 12150, Fort Wayne, IN 46862	Allen	$220,000
BW P-6029	Computer-Videodisk Interactive Training	LaserLearn, Inc.	Dr. D. Craig Hane	(812) 232-0753	120 South 7th Street, Terre Haute, IN 47809	Vigo	$950,000

PRINCIPAL INVESTIGATOR DIRECTORY September, 1988

PROJECT	TITLE	SUBMITTOR	PRINCIPAL INVESTIGATOR	PHONE #	ADDRESS	COUNTY	COMMITMENT
DS P-6032	D-Tech for Underground Storage Tanks	D-Tech Corporation	Dale L. McClain	(317) 576-9777	6801 Hillsdale Court, Indianapolis, IN 46250	Marion	$550,000
RM P-6038	Batch/Semicontinuous Process Software	Batch Process Technologies, Inc.	Dr. Girish S. Joglekar	(317) 463-6473	1291 E. Cumberland Ave., West Lafayette, IN 47906	Tippecanoe	$240,000
BW P-6042	Bioconversion of Renewable Resources	Purdue University	Dr. George T. Tsao	(317) 494-7022	LORRE, A.A. Potter Center, Purdue Univ., W. Lafayette, IN 47907	Tippecanoe	$99,000
CP P-6043	Yes/No Test for Cocaine	GDS Technology, Inc.	Dr. Surendra K. Gupta	(219) 264-7384	25235 Leer Drive, Elkhart, IN 46514	Elkhart	$666,509
BW P-6047	Cell Seeding for Prosthetic Arteries	Endotech Corporation	Anthony J. Hubbard	(317) 872-8988	8910 Purdue Rd., Suite 150-9, Indpls., IN 46268	Marion	$1,170,000
CP P-6049	Heating and A/C Unit with Variable Modes	Artesian Building Systems, Inc.	Maurice A. Rice	(317) 448-4538	100 Creasy Lane, P.O. Box 6296, Lafayette, IN 47905	Tippecanoe	$684,460
BW P-6053	Powder Actuated Tool	AVTEC R&D Corporation	Thomas E. Clumb	(317) 636-1661	3455 East St. Clair St., Indianapolis, IN 46201	Marion	$990,000
RM P-7001	Institute for Molecular & Cellular Biology	Indiana University	Dr. Rudolf A. Raff	(812) 335-4183	Jordan Hall 322A, Bloomington, IN 47402	** Monroe	$872,076
RM P-7002	Scheduler's Tool Kit for Manufacturing	Factrol Inc.	Dr. Hank Grant	(317) 463-3637	P.O. Box 2500, West Lafayette, IN 47906	Tippecanoe	$600,000
BW P-7004	Modoc Catfish Farms	Modoc Catfish Farms, Inc.	Charles A. Wolf, III	(317) 241-9279	4000 N. Meridian Street, #12-J, Indpls., IN 46208	Marion	$561,010
BW P-7005	Lost Foam Casting	Rikker Technologies, Inc.	Leslie D. Rikker	(219) 932-1079	4527 Columbus Avenue, Hammond, IN 46327	Lake	$1,563,642
BW P-7007	Rotating Anode Micro Focus X-Ray Tube	Micro Focus Imaging Corporation	James Grichnik	(219) 931-7979	1741 Summer Street, Hammond, IN 46320	Lake	$500,000
CP P-7009	Optimization of Polymer Molding	Technalysis, Incorporated	Akin Ecer, Ph.D.	(317) 291-1985	7120 Waldemar Drive, Indianapolis, IN 46268	Marion	$700,000
BW P-7010	Cemkote for Aluminum Surfaces	McComas Industries, Inc.	Richard A. Hutchinson	(317) 356-5009	2525 N. Shadeland Ave., Indianapolis, IN 46219	Marion	$246,017
RM P-7012	Expert System Communication Network Design	Network Synergies, Inc.	Curtis G. Gray	(317) 742-9000	330 Main Street, Lafayette, IN 47901	Tippecanoe	$484,000
RM P-7013	Autoanalyzers and Diagnostic Data Base	Applied Physics, Inc.	David B. Doty	(317) 497-1718	1291E Cumberland Ave., P.O. Box 2368, W. Lafayette, IN 47906	Tippecanoe	$285,500
BW P-7014	Computerized Management System	TEKSYM, Inc.	Gerald V. Roch	(317) 875-9750	8650 Commerce Park Place, Suite J, Indpls., IN 46268	Marion	$291,525
RM P-7015	Agricultural Biotechnology Center	Purdue University	Dr. Thomas K. Hodges	(317) 494-4657	Dept. of Botany and Plant Pathology, P.U., W. Laf., IN 47907	** Tippecanoe	$1,190,000
RM P-7019	Engineering Mechanics Design Tool Kit	Modern Computer Aided Engineering, Inc.	Dr. Khosrow Nematollahi	(317) 497-1550	1231 Cumberland Avenue, Suite A, West Lafayette, IN 47906	Tippecanoe	$467,967
* P-7023	In-Home Technology for Education	Technology Management, Inc.	Kent L. Wall	(317) [illegible]36-3566	101 W. Washington St., Suite 905-E, Indianapolis, IN 46204	Marion	$30,000
CP P-7024	Videocassette Programs for Adult Literacy	Mid-Com, Inc.	Jack A. Fenimore	(812) 473-0533	2148 N. Cullen Avenue, Evansville, IN 47715	Vanderburgh	$54,400
CP P-7025	Expert Systems W/Custom Inference Engines	Expert System Partnering, Inc.	David Bartkus	(317) 463-0098	P.O. Box 618, Lafayette, IN 47902	Tippecanoe	$683,330
CP P-7026	Lap Computer for the Visually Handicapped	Computer Aids Corporation	William L. Grimm	(219) 422-2424	124 W. Washington Blvd., Suite 220, Fort Wayne, IN 46802	Allen	$275,500
* P-7028/ 7029	Indiana Superconductivity Center	Purdue University / Notre Dame	A.I. Schindler, D.Sc.	(317) 494-5567	Materials Engineering & Physics, W. Lafayette, IN 47907	Tippecanoe	$587,450
* P-7030	Midwest Plant Biotechnology Consortium	Purdue Research Foundation	Darin Schumacher, Ph.D.	(317) 494-8954	Purdue Research Foundation, W. Lafayette, IN 47907	Tippecanoe	$124,096
BW P-7035	Biotechnology Derived Crop Plant Hybrids	Phyto Dynamics, Inc.	A. Charles McBride, Ph.D.	(317) 296-3497	P.O. Box 5418, Lafayette, IN 47903	Tippecanoe	$368,000
CP P-7036	Perspective Immunoassays	American Monitor Corporation	Marcia J. Arentz	(317) 875-6105	5425 W. 84th St., P.O. Box 68505, Indianapolis, IN 46268	Marion	$1,277,282
BW P-8003	Automated Separation for Black Walnuts	Indiana Walnut Industries, Inc.	Norman O'Bryan	(317) 583-4886	445 Lourdes Lane, Lafayette, IN 47905	Tippecanoe	$465,400
BW P-8009	Flexible Equipment Design System	Streamline, Inc.	Stephen J. Recobs	(317) 674-8551	11711 N. Meridian St., Suite 780, Carmel, IN 46032	Hamilton	$154,000
BW P-8016	Mfg. Tech. Field Service Pilot Program	Corporation for Science & Technology	CST Staff	(317) 635-3058	One N. Capitol Ave., Suite 925, Indianapolis, IN 46204	Marion	$200,000
94 Total Projects						TOTAL	$48,086,585

- Projects which have received supplemental funding.

* - Signifies county where supporting research is being conducted.

** - After completion of the research, all counties in Indiana will be considered as possible sites for the commercialization of this project.

Senator CONRAD. Let me ask you about this initiative at the Federal level. Based on your experience, is this something we ought to pursue at the Federal level?

Dr. GAGE. Yes, it is. My experience includes not just work in the Midwestern States. It is also includes 9 years spent here in Washington, 7 of which as a Federal R&D administrator. And so I say, most definitively, this is just the type of instrument that we need, if the Federal Government, and I am not entirely convinced of this, but if the Federal Government is to move into the area of helping development.

I think the past efforts of the Federal Government to subsidize large development projects very heavily have not worked all that well. I think the Federal Government has generally overwhelmed the private sector in that regard.

The private sector really needs to have its head in terms of making the kinds of engineering business market financial decisions without the heavy hand of the Federal Government involved.

That is why I personally am very much in favor of this type of an organization which can stand at arm's length from the Federal bureaucrats—and I was one myself at one time—stand at arm's length from the Federal bureaucrats, yet still have adequate control, good fiscal control, and can have a real chance to affect the market process.

Senator CONRAD. We set up this as independent from USDA. We did it initially because that was the recommendation of the task force, but in thinking of why the task force made the recommendation and also just in following our own experience, frankly what I was concerned about is the possibility of politicization of the funding decisions. We do not want to do that.

Down that road lies the road to a guaranteed failure. We very much wanted to see something that bridges this commercialization gap that is out there. In all of the testimony that I have heard, and I have had a lot of hearings in this subcommittee, it is very clear we have a problem. We have a need to bridge this gap between basic research and commercialization, and it is increasingly clear the Federal Government needs to play a role.

Yet we want it to play a role that is a productive one, not counterproductive, and we do not want to politicize the process. That was the notion of having an independent board. After the discussion you had on the first point that you made about an outside board, I am personally convinced that we ought to take this additional step and make it even more independent in terms of the Board of Directors.

Well, enough of that. I deeply appreciate the counsel that you have given us, and I think it is a real contribution to our understanding of how to proceed.

Next we will hear from Mr. Michael Aube, the president of the Eastern Maine Development Corporation of Bangor, Maine, on behalf of the National Association of Development Organizations. Welcome.

STATEMENT OF MICHAEL W. AUBE, PRESIDENT, EASTERN MAINE DEVELOPMENT CORPORATION, BANGOR, ME, ON BEHALF OF THE NATIONAL ASSOCIATION OF DEVELOPMENT ORGANIZATIONS

Mr. AUBE. Thank you, Mr. Chairman. I will very briefly paraphrase my prepared statement. I am pleased to be here today on behalf of the National Association of Development Organizations. It is fortunate that this hearing coincides with our rally today "Invest in Rural America," and that is why I am wearing this button.

We have had our entire board of directors in from throughout the 44 States where we do have members meeting with people on the Hill in both the House and Senate to discuss the very issues that you have been raising today.

Our association, NADO is 20 years old, and has been involved in rural development activities for these numbers of years. We have survived in the last few years trying to cope with a 74 percent cut in rural programs and how they affect our areas.

Most of our organizations work in areas where there are, in my opinion, Senator, maturing industries: agriculture, forestry, and from our own example in eastern Maine, they are certainly two major components, and I would add fisheries as a maturing industry. The difficulty we have is that those rural areas have yet to really share in the economic opportunities that are happening elsewhere.

In great part, it is because a retooling or a rechanging of philosophy in agribusiness or major forest products initiatives. These businesses must retool and modernize in order to compete with their markets. As a result, however, we continue to see double digit unemployment rates, and we continue to see communities become more desperate.

Our organization, the Eastern Maine Development Corporation (EMDC), which is a mirror of NADO's 200 members which we have around the country, provides a variety of services. Among them is business counseling, business management assistance and investments. We have at Eastern Maine Development Corporation over $7 million in our loan fund/equity fund. We wear two hats. We do have an equity fund as well as a loan fund, and I was surprised to learn that $100 million nationally did not make much sense when we have already invested $7 million in six rural counties in eastern Maine in about 5 years.

The need is tremendous. EMDC works collaboratively with our sea grant/land-grant university, the University of Maine. They in turn help us with the research. Last year alone our organization counseled over 700 businesses within our area, either new businesses or existing businesses. Not all of these, of course, are agriculture or forestry or fisheries, but predominantly they are. If you examine the economy of our region, that is the foundation of our economy.

The biggest need these people have is bridge financing. That is why this bill is critical. We have worked with private investors. We have worked in our organization in a delivering system to put together funds from venture capitalists in Eastport, Maine, the most eastern point in the United States.

And were it not for the kind of activity that we were undertaking in a collaborative effort with the university, and with the resources of our organization, I daresay those ventures would not have occurred. These are not anecdotes. I think they can be proven by statistics.

Senator CONRAD. Eastport?

Mr. AUBE. Eastport, Maine.

Senator CONRAD. Is that anywhere near Kennebunkport?

Mr. AUBE. No, quite a distance, and also you would find a difference in price of homes in those areas, Senator.

Senator CONRAD. I see.

Mr. AUBE. That project, just to be very brief, is the raising of Atlantic salmon in cage sites. It was a technology that was developed by the Canadians, and they came to our organization and the university and we have worked with them. Since 1983, over $28 million of the institutional venture capital fund has gone into that enterprise.

However, from the time of 1982 till late 1983 when the money came in, and it continues to come in, it was the small moneys like EMDC's revolving loan fund program, our equity injection of small amount of moneys, less than $1 million in this case, which bridged, which got the company to the point where they could attract these venture capitalists' funds.

They now employ a fair number of people, and are now the largest aquaculture salmon raising enterprise in North America, both Canada and the United States. There is one point I would like to make. I think what we see in many of our rural areas, and our other district's members could address this as well, is our role is where the rubber hits the road, if you will.

Our organizations are involved with the business and private sector. We are involved with local communities. We are involved with our research institutions. And, a real need we have is to provide the bridge financing for private ventures.

It is absolutely critical in my estimation at this point in time. And that leads me to recommend that this legislation be heartily supported by other members because the need is there. I think your comments about the need to change institutions, the need to restructure the way we think is absolutely critical if rural areas are going to share in the opportunities that are out there.

One example, and what we are giving out to everyone today—and I had the opportunity to come by your office earlier, Senator—are chopsticks that are being manufactured with aspen in the iron ore range in Minnesota. An area of high unemployment.

Were it not for the Federal Government's investment in these facilities, these people would not be in the business of exporting chopsticks to the Japanese. They are now the world's largest manufacturer of chopsticks, using aspen, the right kind of species.

Many more opportunities like that exist, but what we need is help, and not only help from the standpoint of the Federal Government, which has a responsibility to help organizations like ours who try to work in rural areas to build up the confidence and to do these things. We need the financing. I have gone on probably too long. But those are just general comments, Senator.

[The prepared statement of Mr. Aube follows:]

NADO

NATIONAL ASSOCIATION OF DEVELOPMENT ORGANIZATIONS
400 North Capitol Street, N.W., Suite 372, Washington, D.C. 20001 202-624-7806

Testimony of:

MICHAEL AUBE

President of the

Eastern Maine Development Corporation
Bangor, Maine

On Behalf of The

NATIONAL ASSOCIATION OF DEVELOPMENT ORGANIZATIONS

Before the

Subcommittee on Agricultural Research, and General Legislation
Committee on Agriculture, Nutrition, and Forestry
The United States Senate

On

Agricultural Research Commercialization Act of 1988

June 6, 1988

Washington, D.C.

Mr. Chairman, members of the subcommittee on Agricultural Research and General Legislation, I am Michael W. Aube, President of the National Association of Development Organizations (NADO) and also President of the Eastern Maine Development Corporation of Bangor, Maine.

I would like to thank you, Mr. Conrad, for inviting NADO to be represented at these hearings today. Our members are aware of the leadership you are providing toward better understanding the needs of rural communities. We are pleased to take this opportunity to comment on the challenges facing rural America, and in particular, the needs of programs which promote economic development and diversification throughout our great nation.

NADO was founded in 1967, a group of economic development districts to encourage the creation and retention of jobs in rural America. Today, our members are multi-county planning and development organizations, as well as other state and local agencies which help local governments and the private sector work together on business, community and economic development programs. With a small Washington staff and a strong grassroots network, NADO carries out a number of information, training and service functions.

NADO members serve rural and small metropolitan areas across the country. In the areas where our members work, they are concerned about the economic well being of a substate region, rather than a single political jurisdiction. For many communities, the development districts' staff provide the only professional assistance to governments, business and citizens in the field of economic development. By working cooperatively through development districts, local governments and the private sector can maintain and create jobs with a minimum of participation. Development districts have become an essential part of the "institutional infrastructure" in much of rural America.

For small metropolitan and rural communities, the Economic Development Administration (EDA), Appalachian Regional Commission (ARC), Farmers Home Administration (FmHA) and the Small Business Administration (SBA) are the federal programs which have been of the greatest value.

Today, however, I would like to focus my testimony on the pending legislation, S. 2413, An Act to Create the Agricultural Research Commercialization Corporation (ARCC).

For the most part, natural resource industries continue to be the economic foundation for most rural areas. Unfortunately, all of these industries, in various degrees, display the symptoms of mature industries. Among these symptoms are slow growing markets, limited product differentiation and stiff competition from foreign producers. The result is little or no employment growth. In fact, if our maturing industries desire to compete, they must retool and modernize, resulting in significant economic dislocation of workers. Therefore, rural America's economic base faces a continuing and protracted decline.

Expanding economic opportunities in rural areas require a cooperative effort that harnesses the resources of the business community, public and private educational institutions, and government. Each entity has independent and collective leadership responsibilities in charting the future. The development districts represent a model for this partnership, and more importantly, can nurture and cultivate regional strategies.

At Eastern Maine Development Corporation, as well as at many other similar organizations throughout our country, public-private partnerships in the truest sense are being fostered.

Let me cite a few examples from my own organization in Bangor. EMDC serves six rural counties in eastern Maine. Our board of directors is made up of public and private officials from all walks of life. Our regional strategy is to work cooperatively with government, private sector and the University system to improve economic opportunity within our area. The development corporation is the focal point for this effort. The development corporation acts as a catalyst for collective efforts.

For example, last year EMDC counseled well over 700 business clients. Most of these are entrepreneurs who seek assistance in financing, planning and marketing. We have developed a formal role with the University in which they will provide research and development expertise through their sponsored programs and other programs to our clients. In addition with University faculty EMDC has sponsored inventor workshops to solicit new entrepreneurs. Through a joint effort, the University and EMDC will assist new businesses to obtain patents for their new product or service. Being a land grant, sea grant university, the University and EMDC concentrate on natural resource-based businesses.

EMDC's role usually evolves to assisting the business client in securing financing through our own revolving loan fund, equity fund, and relationship with public and private venture capital fund, or private lending.

However, there remains a significant need for bridge financing. All too frequently, we have been unable to obtain equity capital or private financing because of the embryonic stage of the venture; yet, the research has been completed. What remains to be done is the commercialization. I can say unequivocally, that only local revolving loans have attempted to solve this dramatic need.

The legislation which is being proposed today goes a long way to meeting this critical need. From my point of view, although they are risky, investments in the commercialization of industrial products and processes using agriculture and forestry resources are essential to the survival of rural areas. Rural areas must be able to share in the economic opportunities of our nation. Only by making new technological breakthroughs in the economic foundation of rural areas will success be accomplished.

I applaud your efforts and support this legislation enthusiastically. Thank you.

Senator CONRAD. We very much appreciate your observations. Let me follow up on several things that you have talked about because I caught very early on your mention of equity fund.

Mr. AUBE. Yes.

Senator CONRAD. Part of the $7 million that you have is a revolving loan fund, as I understand it, and part of it is an equity fund.

Mr. AUBE. That is right.

Senator CONRAD. You heard the conversation that Dr. Gage and I had about the question of whether the Government ought to be involved in the equity business. Could you tell us a little about how you operate in that area and whether you would recommend that we alter this legislation to be able to take equity positions?

Mr. AUBE. We have found in working with the businesses in our area that each client is different. The needs are different. I think I would stress flexibility, and if we are talking about restructuring institutions, we ought to think in terms of that.

Our organization has an equity fund completely separate because that is what is needed in some cases. Frequently, we will even design a loan so that the kicker, if you will, the repayment is such that it could be construed as equity.

Each case is different. In the case of Ocean Products Inc., in the Atlantic salmon deal, if we did not have the capacity to provide some equity financing at a point in time, that critical point in time, I do not think it would have happened because what we have learned in that instance, as well as others, is when you start dealing with institutional venture capitalists, they are already debating and developing their strategy for the take over of the company.

And as a "public entrepreneur" we have to determine at what point in time in the financing—is it round one, round two, round three—will there be a move to take control of this? What we were able to do with the equity injection at the appropriate time was delay that so that the local management, if you will, would be able to participate a little longer in the company.

And that is, I think, a major detriment to just having a loan fund because institutional venture capitalists will tell you their strategy is eventually to make a lot of money, go public with it, and control it. And when they make their earlier decision to come in, it usually means they are there for the third and fourth round financing as well, but demanding more of that pound of flesh, if you will.

Senator CONRAD. I would be interested in your reaction to the question of the makeup of the Board of Directors. What is the makeup of the board of directors of your operation?

Mr. AUBE. Our operation is made up of a 15-person board of directors, chosen from its corporators. They are totally independent.

Senator CONRAD. All 15 are totally independent?

Mr. AUBE. Absolutely. All 15. We have a geographic requirement, and so I would concur with Dr. Gage's assessment that it should be more independent. I think that, again, gets back to rethinking of institutions and how we deal with issues.

Senator CONRAD. Let me also ask you about proprietary rights. Dr. Gage and I discussed this. Dr. Gage brought it up. What is the position that you take with respect to proprietary rights?

Mr. **Aube**. We have not gotten involved in those types of issues. The university which provides both financing, our university, both financing and assistance in the whole patent issue will sometimes get involved in those issues, but we as a nonprofit development corporation have stayed clear of those for a variety of reasons.

Senator **Conrad**. Very well. I am also interested in the whole notion of the repayment schedule. What have you done on repayment? How do you handle that? Is yours designed to be a revolving fund?

Mr. **Aube**. Yes, it is.

Senator **Conrad**. In the sense that it is self-sustaining?

Mr. **Aube**. Yes, it is. And we are always seeking new moneys obviously to inject, but it is meant to be a revolving loan fund. It was initially capitalized by EDA. We have since gone out and received private financing and other moneys to keep that thing alive and make it grow. I think our intent, however, is to remain as flexible as possible. I think that is really the key, and frequently we will structure a deal and we are going to take 2 percent or 10 percent, whatever rate you want to get. You, however, have to adjust.

Circumstances, in particularly early enterprises, in the embryonic stage, change so dramatically. Management, we have found, changes two or three times. And the key is management, management, management. We find one thing you have to have organizations that can really help and nurture these businesses.

You cannot just give them the money and walk away. If you are going to be fiscally responsible and if you want to see a return, you have to work with them all the time. That would be some suggested changes I would have to the legislation. You really need to work with these people.

And once you make an equity investment, however, then you obviously are in a more difficult position to make management suggestions. So that is a distinction that you have to look at on a case-by-case basis.

Senator **Conrad**. All right. Thank you very much for taking the time and making the observations that you have. It is very helpful to this subcommittee and I think ultimately helpful to getting legislation like this moved. My final question would be I take it that you, too, would support the thrust of this kind of legislation: that the Federal Government ought to be moving in this direction?

Mr. **Aube**. Absolutely. I think it is a responsibility and an investment the Federal Government must make.

Senator **Conrad**. All right. Thank you, both of you. We very much appreciate your participation. Next we will hear from our final panel made up of Dr. Melvin Blase; Dr. Gary Jolliff, professor of crop science, Oregon State University; and Scott Shearer, the executive director of the National Corn Growers Association, St. Louis, Missouri. Dr. Blase, I notice is a professor at the University of Missouri-Columbia. I attended the University of Missouri at Columbia for a year, and so it is like a homecoming—1966–67 school year I was there.

Dr. **Blase**. First year I was on the faculty.

Senator **Conrad**. Oh, really.

Dr. **Blase**. Turns out to be a small world.

STATEMENT OF MELVIN G. BLASE, PROFESSOR, AGRICULTURAL ECONOMICS DEPARTMENT, UNIVERSITY OF MISSOURI-COLUMBIA, AND COORDINATOR OF THE HIGH ERUCIC ACID OIL PROJECT, COLUMBIA, MO

Dr. **Blase**. I appreciate the opportunity of visiting with you concerning this legislation. I am primarily speaking from the position as coordinator of the high erucic acid oil project, sometimes referred to as the crambe-rapeseed project. Also, I was a member of the task force and have been very interested in some of the earlier discussions this afternoon.

I am going to try to do two things. One, to give some illustrations of products that might result from agriculture in this general area. Secondly, I would like to address several issues in the legislation itself.

As far as uses of agricultural resources are concerned, I would like to divide this discussion into two component parts. I am going to give more illustrations from the high erucic acid oil area than others, but I want to conclude this section of my presentation with enumeration of several potential products that might be forthcoming from other crops, also.

In our project area a group of universities are working with USDA—namely North Dakota State, University of Idaho, New Mexico State, University of Nebraska, Kansas State University, University of Missouri-Columbia and Iowa State University—in trying to move toward the commercialization of crambe and rapeseed. I have some illustrations here, first of all, of the two seeds involved.

That is crambe. And some is being raised in North Dakota this year. This is rapeseed. Both of them produce a high erucic acid oil which is sometimes described as a "chemist's dream."

The chemical properties of the oil are such that it has a long-chain fatty acid. It is presently used in such a common thing as bread wrappers, and in other plastics such as garbage bags—in both cases as slippage agents. You may remember in the "old days" plastics used to stick together. The reason that this does not happen now is because there are minute amounts of erucic acid from these crops in these products.

But in addition to these uses, this oil has a very interesting set of properties that holds promise for other uses. This sample of the oil is approximately 15 years old. You will notice that it is still relatively clear. If you were to open it and smell it, you would note that it has not turned rancid. It is a very interesting product that, in fact, has a remarkable degree of stability.

One of the uses that is made of it is these nylon pellets, nylon 13-13. Nylon 13-13 can be used for a variety of products, one of which we are cautiously optimistic about—illustrated by these chips—in the automobile industry because there is the possibility of making parts for under the hood of an automobile, that is, hoses, gears, et cetera, out of these products.

The automobile industry has indicated interest in nylon 13-13. The problem in the past has been cost. By using a systems approach we work simultaneously at getting the cost of production reduced as well as work with firms in introducing these things in the marketplace.

In working with industry, we have found that they have two reservations with regard to working with agricultural feedstocks. One is that they are concerned about dependability of supply.

The second is about what role will Government assume.

One of the other uses for which I have not brought an illustration is an ingredient in motor oils. This is another illustration of where a systems approach is necessary. We are in conversation with a manufacturer of ingredients of motor oil, a firm very, very much cognizant of what the high erucic acids can do. They are very much concerned and interested, but they are concerned again about costs. So we have attempted to assure them by using a systems approach. We are trying to simultaneously reduce the cost of production of the product on the farm and also work with them in introducing the product into the marketplace.

Now I do not want to spend all my time talking about my pet project, so let me continue with several other examples. We have had some discussion of kenaf. This is a stalk of kenaf. That is a newspaper made from kenaf. And you will notice that the newspaper is almost a year old.

Senator CONRAD. The stories are just as bad though as in my paper.

Dr. BLASE. They have not changed a bit, have they?

Senator CONRAD. How about the editorial policy? Does that help any?

Dr. BLASE. I happen to have a very keen interest in that particular activity because the executive of the kenaf project was my graduate student several years ago. His Ph.D. dissertation is, in a sense, the strategy that is being used for the commercialization of that crop.

I would like to use that as an illustration of something that I am not sure we have emphasized enough today, and that is the whole question of risk. This is a high risk business.

I think the risk factor is something we need to recognize. This underscores the need for the flexible bridge financing that we have alluded to.

Another activity that has been referred to is guayule rubber. This is a tire made of guayule. And as has been mentioned, this is a project in which the Defense Department is very much concerned.

My final illustration is, if you please, some milkweed. This milkweed product that can be used as insulating material for such things as sleeping bags. If you like, you can put it on the table and put a drop of water on it, and you will see that it stands there like a bead rather than to be soaked up. I understand that folks who sleep in sleeping bags do not like to sleep on soggy ones.

Well, the point that I am trying to make with all of this is that there are a number of opportunities for agricultural resources to become feedstocks for the industry of this country. As a former member of the task force, I think part of our thinking needs to be put in perspective with regard to scale.

As a task force, we set out a national objective of shifting 150 million acres to diverse uses. This means that it is not something that we can do by nibbling around the edges of the problem. I think part of the differences that we heard earlier today has to do with the question of the scale of activity, how ambitious we want to be in this general area.

Senator CONRAD. The question has become whether we want to be ambitious at all.

Dr. BLASE. How aggressive we want to be. I have done a lot of work in developing countries, and I have been in and out of Korea on several occasions. One of the things that has impressed me over the years has been that the public and private sectors tend to work together rather than as adversaries. And I cannot help but think that that is one of the reasons why we are perhaps finding the Koreans very difficult competitors in the international marketplace. Now this suggests a different philosophy from which we have had in the past. It is a departure. It is something I think we need to think about.

I would like, with your permission, to enter these two publications into the record because they give more information about a number of other products that can be, in fact, produced from agricultural feedstocks.

The CAST Report, report No. 102, October 1984, "Development of New Crops: Needs, Procedures, Strategies, and Options," which preceded the task force and the "Growing Industrial Materials: Renewable Resources From Agriculture and Forestry," October 1, 1984, a publication of the U.S. Department of Agriculture.

[Publications supplied by Dr. Blase are retained in the subcommittee file.]

Dr. BLASE. And now with your permission, I would like to shift to the legislation itself and make several comments. First of all, I would suggest that, based upon our experience, it is not useful to draw a hard and fast line between research and commercialization.

In the high erucic acid oil project, we make certain investments that could be categorized either way. For example, if you have to put the oil through a chemical process—a chemical change that has not been done before in the United States—that you need to, in order to come up with the end product you are targeting, is that commercialization or is that research?

And so I would suggest that it would be perhaps incorrect to try to draw a firm line between the two. They are really on a continuum. You need to have some flexibility in each situation in terms of how much you invest in the basic research areas compared to the strict commercialization.

Second, I think while we need to make clear that the focus is on nonfood, nonfeed products, we have to also recognize that there are some dirty shades of gray here, also. For example, the two seeds that you have before you, crambe and the rapeseed, after the oil has been extracted are good protein supplements for livestock, that is, there is a feed use. Does this mean we disqualify these crops because of the fact that a byproduct is a potential livestock feed?

I would suggest that we might not want to establish a prohibition in those instances where you get, in fact, a byproduct that is in the feed area, even though the primary reason that the product has been worked with has been in the industrial area.

Third, I would suggest that there be a directive that ARCC and the Regional Centers be directed to work with the land-grant universities and other USDA Centers. It would be most unfortunate, indeed, if they were to work in isolation. There is much to be learned from the existing resource base and the institutional base. So it would be highly desirable for them to be mandated to network from the very outset.

With regard to the regional councils, my own preference would be that they perform more than just an advisory role. In fact, I recommend they employ the regional executive directors because our experience with the high erucic acid oil project has been that those decisions need to be made close to the scene. I think that it might not be useful for all of those positions to be filled from Washington.

Fifth, I would suggest that it would be misleading, perhaps mistaken even, to specify that the backgrounds of the people involved should come from the scientific, engineering area. In fact, there is perhaps as much need for good business sense, a good business economics background, as any particular disciplinary. Perhaps it is not appropriate to specify disciplinary backgrounds at all.

Sixth, I would hope that there would be some spending level that the regional director, under the supervision of the regional board, could have such that not all proposals would have to be sent to Washington. I would suggest, somewhat arbitrarily, that a cap of $1 million a year per project be placed on the Regional Center so that there is not a cumbersome, time-consuming process that is required for a small project as for the large ones.

One of the things that my colleagues will frequently remind you of, if you visit with them, is that you have to do as much work in terms of proposal writing, et cetera, to try to get a small grant as a large one, in many cases. And as a result, what do people do? They go after large ones. There needs to be some incentive for modest grants to be handled at the local level.

Seventh, I would suggest that the membership on the corporate board would not include the regional executive directors. I would be much more comfortable with a 15-member board. My own preferences run along the lines of 5 of these being from the private sector, 5 from academia, and 5 from the public sector.

I feel very strongly that the private sector needs to be represented in order for this entity to have legitimacy in the private sector.

Eighth, I find myself in agreement with the idea of the firm being able to take equity interest in new ventures. Perhaps even better than that, the testimony that just preceded us with regard to having both types of investment possibilities has merit.

Let me go back to my point about risk. I think if we are really honest about this, we will recognize that the failure rates may run as high as 50 percent. And if this entity is to be self-funding, then there has to be some way that these lost resources will be recouped.

One of the models that we used in the task force was a British entity. In that case the experience had been that there was one investment that is now primarily funding through dividends, the entire activity.

The point is that there is a distribution of probable outcomes. It is uncertain as to exactly which of the firms will be highly profitable and which ones will, in fact, fail. There needs to be an opportunity for equity investments so that the funding agency can benefit from those that are the fantastic successes, as well as "bite the bullet" in the case of those that are failures.

I concur with one previous witness who suggested that the term "cooperative agreements" be provided for. This is one of the most flexible, useful contracting mechanisms available to government, and I would strongly recommend that provision be made for its incorporation.

Finally, recognizing that there are differential rates of acceptance within USDA as far as this work is concerned, I would hope that companion legislation that would reauthorize the Office of Critical Materials would move forward so that there can continue to be a "friendly home" in USDA for new crop efforts.

I would like to conclude my testimony by reading one paragraph of my prepared statement:

The work that remains to be done will not be easy. Our work has taught us that many private firms are apprehensive both about private/public sector partnerships and depending on the agricultural sector for a reliable supply of feedstocks at stable prices. Clearly, imaginative approaches will be required. New ideas need to be forged. Leaders in agriculture need to dream new dreams. Risks must be taken. A new mentality must evolve. I see the Agricultural Research Commercialization Corporation (ARCC) as a critical step in that direction.

Thank you, sir.

[The prepared statement of Dr. Blase follows:]

STATEMENT OF MELVIN G. BLASE, PROFESSOR, AGRICULTURAL ECONOMICS DEPARTMENT, UNIVERSITY OF MISSOURI-COLUMBIA AND COORDINATOR OF THE HIGH ERUCIC ACID OIL PROJECT

Mr. Chairman, members of the Committee, I appreciate this opportunity to (1) discuss potential new farm and forest products and (2) comment on S. 2413 introduced by Senator Conrad for himself and others. This will be done primarily from my vantage point as Coordinator of the High Erucic Acid Oil Project. Brief comment about that project is in order prior to turning to my primary subjects.

The High Erucic Acid Oil project has the objective of commercializing products from crambe and high erucic acid rapeseed. A systems approach is taken so that all the functions involved in the production, marketing and consumption of the end products are considered from the criteria of physical possibilities, economic feasibilities and institutional permissibilities. With this Production-Marketing-Consumption (PMC) Decision Matrix we are concerned with all functions from genetic manipulation to market penetration for the final product. This approach has been characterized by one observer with the following statements, "If cotton were the new crop, you would be concerned with everything in going from dirt to shirt." This comprehensive development design is being undertaken by seven universities in collaboration with the Office of Critical Materials, USDA. The universities involved are North Dakota State University, Iowa State University, University of Nebraska, Kansas State University, New Mexico State University, University of Idaho and University of Missouri-Columbia. Our current primary focus is on market development, with more than 50 percent of our FY89 budget request allocated to that general area. In turn, most of these funds are destined to be passed through the universities to private firms for market development research on specific products primarily made from high erucic acid oil.

POTENTIAL NEW FARM AND FOREST PRODUCTS: EXAMPLES FROM HIGH ERUCIC ACID OILSEED CROPS

If I may, let me illustrate the potential for U.S. agriculture to become a source of feedstocks for industry by using crambe and rapeseed. Presently, the principle market for high erucic acid oil in the U.S. is as a slippage agent in plastics. As an aside let me comment that most of the oil for that use is imported. Ironically, our fledgling rapeseed industry in the Pacific Northwest is exporting much of its output. Suffice it to say, there is both a potential for import substitution and for an export market expansion for this crop.

Our analysis suggests there are three much larger potential markets than the existing ones, however. These are as high temperature lubricants, low temperature lubricants and nylon components for the automobile industry. These deserve elaboration.

HIGH TEMPERATURE LUBRICANTS

By virtue of its chemical composition as a long chain fatty acid, high erucic acid oil is remarkably stable at high temperatures. This characteristic opens a number of market possibilities. Illustrative of these is its use in steel casting. In addition, research is underway into other major potential markets but it would be premature to judge the outcome of the research at this time.

LOW TEMPERATURE LUBRICANTS

Project personnel are in conversation with a major manufacturer in this industry with a view toward joint efforts in product development. Although I am tempted to talk about this at length, let me merely use it as an illustration of the need for a system approach. The firm in question has considerable knowledge about the chemical properties of high erucic acid oils. They find them exciting. The problem has been on the cost side. We have emphasized that our agronomic research component is actively working on methods of reducing the costs of production. Hence, joint efforts on both the side of market development and on the side of reducing the costs of production may open this market.

NYLON COMPONENTS FOR THE AUTOMOBILE INDUSTRY

As a result of research done at the USDA Laboratory in Peoria, IL approximately 15 years ago, nylon 13-13 has been produced from high erucic acid oil. Its properties are such that it could be used for parts "under the hood" of an automobile. Project personnel are contacting firms interested in this area with a view to new initiatives to be jointly funded.

OTHER USES OF HIGH ERUCIC ACID OIL

While the above suggest major market possibilities, there are additional, smaller volume market potentials to be explored as well. Several illustrations suffice. The oil is being evaluated as a floatation agent for the mining industry. One firm said they would consider using it as an ingredient in asphalt for streets if it were cheaper. Another firm believes it can be used as a lubricant for crude oil being pumped to on-shore storage sites from off-shore wells. Fishing line is a possible use of nylon 13-13.

The last use is another actual one. Although usually considered an inedible oil, one firm uses minute amounts of it to keep the oil in peanut butter from separating and rising to the top the way it used to "in the old days."

ADDITIONAL POTENTIAL NEW FARM AND FOREST PRODUCTS

The above list suggests the uses that can be made of one oil. In addition, numerous other new farm and forest products are possible if one starts with other crops. Just as the above list was not exhaustive of the potentials from high erucic acid oil, the following is illustrative of uses that might be made from other crops.

Kenaf International, et. al., are commercializing kenaf for newsprint production, felts and composites.

The prototype guayule processing plant in Arizona will be producing natural rubber for testing in tires by the Defense Department in the near future.

Additional research is being initiated to develop a more acceptable biodegradable plastic bag from corn starch.

Milkweed can produce insulating material much less prone to absorb water than existing material.

Additional potentials for the production of industrial oils are suggested by the following plants and their products: Lesguerella-hydroxy acids; Veronia-epoxy acids, and Cuphea-short chain acids.

Mr. Chairman, rather than elaborate on these many potentials, I request that these two publications be made part of the record. This will enable me to turn to S.2413.

COMMENTS CONCERNING S.2413

Since the High Erucic Acid Oil Project is carrying out some of the activities, albeit on a very small scale, envisioned for the Agricultural Research Commercialization Corporation I would like to offer several comments concerning the proposed legislation.

In my view, this is some of the most important and badly needed legislation introduced this decade. A new approach to agriculture's problems is desperately needed. This legislation is directed at the critical bottleneck in making agriculture a source of feedstocks for industry -- the commercialization of new products and processes. In order for new products to be economically sustainable, the system must be demand driven. Hence, the focus of this legislation on the commercialization process is of critical importance.

Having said that, let me suggest ways of making a piece of good legislation better.

The experience of our project suggests that a distinction between research and commercialization is not clear frequently. They merely represent different ends of a continuum. I suggest that the legislative intent be to avoid either extreme and to use differing mixes of the two as each situation demands.

While I agree the focus should be on commercializing nonfood, nonfeed products and processes, again a clear distinction is not always obvious. I illustrate my point by suggesting that many, if not most, oilseed crops produce a meal that becomes available as a livestock protein supplement after crushing. Does that disqualify the crop from participation? I would hope not.

Turning to the regional centers, if they function in isolation they will be very inefficient. To avoid that unfortunate possibility I suggest they be directed to network with the Land Grant Universities and other USDA centers in their region. Importance needs to be attached to terms such as "collaboration" and "participation", to say nothing of "networking" itself.

I am quite convinced that agricultural processes, being as location specific as they are, require a maximum of control by people on the scene. Hence, I would suggest that the Regional Councils be more than advisory in nature. For example, I feel strongly that they should have the authority to hire the Regional Director rather than the Secretary. Further, I would suggest that that person might be as well as or better qualified coming from a background of business/economics as scientific/engineering. Unfortunately, disciplinary prerequisites are difficult to stipulate in this area.

Requiring that all proposals, regardless of size, be subjected to the same review process would be a mistake in my judgment. I recommend that each regional director be given authority to spend up to $1,000,000 per year or $5,000,000 accumulated over the life of a project prior to requires approval at the national level. Of course, this would have to be under the approval of the Regional Board and would have to be adjusted for inflation over time.

My recommendations concerning the Corporate Board of Directors will be made more forcefully than any others. I have very strong views at this point. First, the Regional Directors should be ex-officio members with voice but not vote. The ultimate decisions must be made by totally disinterested personnel. Second, the 15 member voting board should come from designated areas. My feeling is that five should be required to come from the private sector, five from Colleges of Agriculture in Land Grant Universities and five from the public sector. Finally, serious consideration should be given to asking established organizations in each of these areas to nominate lists of candidates from which the Secretary would select.

As presently structured, the Corporation will have difficulty being self-funding, in my judgment. This is a high risk activity. Probably more than 50% of the attempts will fail to become commercialized. If this is true and the assumption is made that all projects -- both "winners" and "losers" -- are funded at approximately the same level, half of the funds will be lost by defination. By providing that the remaining loans are repaid rather than enabling the Corporation to assume an equity position in the "winners" the Corporation will not be able to recoup its financial position. My preferences are that the Corporation be enabled to assume equity positions as recommended by the New Farm and Forest Products Task Force.

One final suggestion concerning financial matters. Presently, USDA uses Cooperative Agreements as contractual instruments in working with universities. They are exceptionally well suited for this type of activity -- one that requires a great deal of flexibility in areas such as contractor selection and movement of funds. I feel it is imperative that the legislation provide for their use in this area of work in the future.

Experience has taught our project that not all units of USDA are equally supportive of work on new farm and forest products. I urge that in companion legislation the Office of Critical Materials be reauthorized so that this innovative work will have a "friendly home" in USDA.

The work that remains to be done will not be easy. Our work has taught us that many private firms are apprehensive both about private-public sector partnerships and depending on the agricultural sector for a reliable supply of feedstocks at stable prices. Clearly, imaginative approaches will be required. New ideas need to be forged. Leaders in agriculture need to dream new dreams. Risks must be taken. A new mentality must evolve. I see the Agricultural Research Commercialization Corporation as a critical step in that direction.

Senator CONRAD. I want to thank you very much. I think your testimony was just extraordinarily productive. As you went through the list of recommendations, I found myself agreeing frankly with virtually everyone of them as suggestions that would improve and build upon what we have as a general structure in my bill.

We will reflect on the suggestions that you have made here. Honestly, my initial reaction is that almost without exception the suggestions you made are things that we ought to adopt.

Let me ask you about the one suggestion that I am less sure of: the size of the Board. I very much take to heart your recommendation that we not get tied just to a scientific-technical background in selecting Board members. I think that would be a mistake. Absolutely we need people with a strong business background involved in these boards.

You have recommended a 15-member Board. I must say I have been a little concerned that a 25-member Board would be too large, too unwieldy. That is the size of the Indiana board. But I do have that real reservation.

In my own experience, boards that get beyond even 10 or 12 members get to be unwieldy. A 25-member Board is probably going to create some problems. I would just be interested in further reaction from you on that Board size.

Dr. BLASE. One of the reasons that I suggested that number is that for the last 2 years we have been working with essentially a 12 to 13 person management committee which, in a sense, is my management board. And I would be reluctant to see that expand much beyond what it is now. There are several reasons for that.

We are set up so that primarily the management committee is made up of experiment station directors and directors of cooperative extension. These are busy people. There are times when we have to get decisions made relatively quickly.

It becomes a logistical problem of how do you track a person down and talk to them on the telephone in order to deliberate on a particular issue, if you want a participative Board. Now my biases happen to be in that direction.

Now if the Board is essentially going to be a rubberstamping operation, then perhaps the bigger the better. But if there is really going to be true participation I would much prefer something in the order of 12 to 15.

Senator CONRAD. All right. Let me ask you a more general question. You were on the task force?

Dr. BLASE. That is right.

Senator CONRAD. I would be interested in your reaction to the testimony that we heard from USDA. I found it disappointing because we have tried in large measure to incorporate the recommendations of the task force. I think with the further refinements that have been mentioned here today, we can improve substantially in our initial offering. But I would be interested in your reaction.

Dr. BLASE. Well, I want to make, I think, three comments at this point. One is that the Department has been quite consistent in what it has said. It was very clear at the outset of the task force that we were to consider ourselves as an independent group.

We were not labeled specifically as an advisory group to the Secretary but rather we were set up, we were constituted, as an independent task force, such that, for example, each one of us had to provide for our own funding to get to the meetings.

So this has been consistent all along, recognizing that there were a number of different groups that would hopefully be impacted by our recommendations, not just the Secretary of Agriculture. So I think it is very important that, one, a person recognize that this has been very consistent throughout.

We have been very independent from the word go, and that one understands, then, that there are going to be things that will not always have unanimous opinion by everyone. Some people say the mark of an educated person is being able to agree to disagree.

Second, I think that the Department has made some significant progress with regard to this general area. I started working in this area in 1979. Our initial funding did not come from USDA at all. Our funding came from the National Science Foundation.

There has been remarkable progress made in the interim period with regard to what USDA has been willing to do. Much of the difference is a matter of scope. The task force was remarkably bold for a task force.

Senator **Conrad**. It was very bold.

Dr. **Blase**. In setting forth the objective of 150 million acres, we were bold. We argued quite extensively within the group on this point. Some were more comfortable with 100 million acres and some with 150 million. But the point that was made, and it was made in dramatic fashion by using the 150-million acre figure, is that something has to change.

There have to be some fundamentally new ideas so that agriculture begins to serve not just as a channel for food and fiber production, but also begins to see itself in a new role entirely, looking to itself as being a feedstock for industrial uses.

And I can understand why there might be some within the administration who would not be comfortable with that kind of a task. You need to remember we also put a 25-year timeframe on our recommendation. We are trying to challenge U.S. agriculture, in particular the U.S. Government and the society as a whole. And so a fair amount is a matter of difference in the scale of the undertaking.

I think the third thing is that at the same time that we are moving, part of what we need is to have some small successes. This is a high risk business. When the dividends start coming in to shareholders from kenaf, for example, that is when we will have a lot more people who are going to be willing to put some money on the line.

Much of the technology for making that newsprint and much of the technology for making that nylon 13-13 was developed at the Northern Regional Research Lab approximately 15 years ago.

Now somehow or other, we have to find the bridge that will move those kinds of things into payoff uses more quickly. As we do that, I think we are going to find many more people who are going to be interested in moving in our direction.

As an economic development specialist, I am inclined to think that we do things just backward as far as allocating agricultural research resources in this country. What tends to happen now is that a crop becomes a major crop and an interest group evolves around that crop. It has some political clout.

Research resources are forthcoming as a result. And so we tend to, in a sense, "dig a hole deeper and deeper" by getting more of our resources increasingly committed to established crops many of which are in surplus. Whereas from the standpoint of economic development, what I would like to do is see someone with some vision say, "Let us look at some of these new opportunities where there are not any squeaking wheels. Where there is no special interest group to come to your defense, where it is very difficult for you to find resources, as it now stands, but where we are working with new ideas and new possibilities and new products."

It should not take crops like soybeans 200 years to become a commercial crop in a country like the United States. We have got to find some way to make the process more efficient. But that would run contrary, you see, to the way we are presently allocating our research resources.

Senator CONRAD. Well, thank you for that observation. I could not agree with you more. We are really missing opportunities. I am convinced of that. We are currently being guided by what is, not what could be. If we are going to make use of the extraordinary resources we have, we have to have a policy beyond idling those resources.

It is terribly shortsighted and ultimately a self-limiting game that way. So, again, I deeply appreciate the thought that you have put into this testimony and the effort that you made to be here today. It has been very constructive. I must say that is what helps advance the ball around here is when we try to be constructive about how we proceed. You have done that, and I very much appreciate it.

Next we will hear from Dr. Gary Jolliff, professor of crop science and leader of the New-Crops Research Project at Oregon State University. Welcome.

STATEMENT OF GARY D. JOLLIFF, PROFESSOR OF CROP SCIENCE, DEPARTMENT OF CROP SCIENCE, LEADER, NEW-CROPS RESEARCH PROJECT, OREGON STATE UNIVERSITY, CORVALLIS, OR

Dr. JOLLIFF. Thank you. It is a pleasure to be here and I appreciate being invited to comment on this bill. In the written testimony plus other printed materials that I have submitted for the record and for subcommittee files, I have described my involvement in crop production and in research on the domestication, development, and commercialization of new crops.

Last June 26,[1] I testified before this subcommittee as a member of the New Farm and Forest Products Task Force, and as a scientist in academia, attempting to represent research on new crops in the United States.

I believe that S. 2413 is a very good bill, and I believe there have been some very good suggestions to make it even better. Today what I will do is attempt to convey to you why I believe that S. 2413 is an essential ingredient for the diversification of U.S. agriculture. My examples will be primarily from my personal experience, with the new oilseed crop meadowfoam.

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[1] New Uses for Farm and Forest Products, S. Hrg. 100-471, June 26, 1987.

So my oral testimony is different from the written one which goes into some other matters in more detail. It is well-known that psychology plays a major role in U.S. finance, business and marketing. This is true also in agriculture. The development of new crops and products in agriculture is very vulnerable because the associated psychological swings are often extreme. Most people hope for something for nothing, and we would like to have it tomorrow.

Thus, persons involved in research and development of new crops, to make them profitable seldom have a stable environment within which to work. The majority of the time, the mind-set of colleagues or funding agencies, administrators, or other exterior pressure groups tend to be that of either a panacea, with unrealistic expectations, or extreme disappointment because previous expectations were not met.

These kinds of circumstances tend to give all new crop ventures a bad report or reputation. My investigations have revealed that few, if any, new crop development efforts of the past have been given appropriate attention, compared to the time, resources, and expertise we know that it takes to develop a plant into an economically competitive crop.

This topic is discussed and developed in my manuscript entitled "Strategic Planning for New Crop Development," which I have submitted for the record.

I believe that ARCC can provide a stabilizing force in new crop development projects by keeping expectations in line and by giving appropriate duration to stable programs.

For example, currently the Oregon Meadowfoam Growers Association probably would benefit from the type of focus which ARCC would provide. The Oregon Meadowfoam Growers Association is attempting to coordinate efforts in production, State and federally funded research, oil extraction, oil refining, and market development.

Frankly, I believe that this task is probably too large and too costly to be assumed totally by a small organization of approximately 20 farmers. These growers paid $1,000 each to join the association. The motivation for them to invest in the development of this new crop lies in the exclusive rights given to them by the Oregon Agricultural Experiment Station to grow the first commercial meadowfoam cultivar.

These growers have personally risked hundreds of thousands of dollars in the production of an inventory of raw meadowfoam oil and seed so that industry could be assured of being able to purchase the product, as Dr. Blase has pointed out. And we should note that the first commercial sale of meadowfoam oil was made to Japan, as an export item.

The growers produced this inventory during a period when the oil was selling for $3.65 a pound. It is now apparent that oil prices of $2 to $1.50 per pound will stimulate major market pull and higher volume uses.

It is logical that swift reductions in the price of the raw oil is important to encourage rapid commercialization and market development. My research has been focused on increasing oil yield per acre so that farmers can sell the oil at lower prices and still make a profit without subsidies.

I have developed a new variety of meadowfoam at Oregon State University which could be produced commercially by 1989 or 1990 and sold for $2 per pound. But how soon could these lower prices be offered to industrial buyers?

The oil price will be a very important factor in determining when industry begins to invest more of their resources in oil utilization research and product development. And that R&D pipeline can take several years from the time research is initiated until finished product is developed which creates demand for additional raw materials.

The networking needed to understand, plan, encourage, monitor and fund these kinds of ventures does not exist, but S. 2413 is designed to do that job.

What do the Oregon Meadowfoam Growers do with the oil inventory produced at $3.65 per pound? Should anyone else help absorb the $1.65 per pound extra on inventory oil so that they could sell current product at $2 to immediately generate more market pull and accelerate commercialization?

I believe that the Oregon Meadowfoam Growers Association is an example where they have absorbed more risk than they should need to without a public partnership. What is it worth to try to get a new crop going?

This again illustrates the need for ARCC. I believe that S. 2413 will provide for the kind of public-private partnership plus a critical mass of expertise and resources to optimize the opportunities for the Nation to develop new resources such as meadowfoam.

Similarly, this type of activity could have been the key to the successful commercialization of the pyrethrum crop, a natural insecticide used safely with warm-blooded animals and humans.

However, recent research and development efforts on pyrethrum in Oregon lacked the kind of approach which is proposed for ARCC in S. 2413. So far as I am aware, the venture capitalist who tried to get pyrethrum production commercialized in Oregon may have given up.

It is my opinion that the crop did not get a fair chance. It should be noted that the U.S. imports pyrethrum. Clearly, pyrethrum could be developed for domestic production and export.

How much is it worth to develop alternatives? Do we count the cost of the $300 billion spent on agricultural commodity surplus-related programs during the past decade or so? I believe that new crop development efforts should be made on a level playing field basis with other competing commodities.

It took over 200 years for soybean development in the United States. I think legislation should allow for a 20-year minimum investment in development of a new crop. I believe that S. 2413 will provide the needed objectivity and continuity.

Other crops such as the perennial poppy have been researched in my project at Oregon State University. The alkaloid thebaine could be produced domestically as an alternate to imported opium for medicinal codeine. But the work on commercialization of the perennial poppy had no advocate to help overcome the entry barriers.

And the list goes on. There are cuphea, vernonia, crambe, high erucic acid rapeseed, jojoba, castor, and others. We have known about these plants as potential crops for at least 30 to 50 years. It troubles us to see the progress is so slow.

In my opinion there is clearly one most important need. Some entity in this Nation needs to be given the mandate, the resources, and the accountability to get the agricultural diversification job done.

In the current national agricultural arena, bureaucrats can lose their jobs for taking risks. There are numerous incentives to stay clear of nontraditional agricultural crops, commodities and political support groups. The Nation needs ARCC to get started with a mandate to take good risks.

It is the legislated intent for employees of ARCC to take risks, and they will be expected to take the risks which are in the best interest of the U.S. farmer, taxpayer and consumer.

This has been needed for at least 50 years. I am confident that the establishment of ARCC will encourage a greater number of research scientists in the Nation's universities and businesses to invest their available resources on innovative new crop and new product development ideas.

In the current Federal and State agricultural establishments, it is too easy to jeopardize one's professional future by working on new crop research and development. The stimulus is to work on the major surplus commodities which provide job security and stable funding.

S. 2413 is an important first step to change that situation. I am confident that the land-grant university system and other agricultural State and private institutions will respond to resources directed to the diversification of U.S. agriculture.

My concluding point is a recommendation. That recommendation is expanded in the written testimony presented for the record. Profit drives nearly everything. If profit is large enough, you do not need Federal partnerships or even State agencies doing research or development.

Marijuana commercialization proves this point. However, new crops are virtually by definition not yet profitable. Therefore, some Federal agency must be given the mandate, resources and accountability to invest in research to improve the productivity and the profitability of new crop plants, just as we have done with corn which we will hear about in a moment.

That is the driving force for the long haul, to make wise use of the farm and forest lands of this Nation. Today may not be the time to say more about this need, but certainly it is a topic for consideration by this subcommittee.

And Mr. Chairman, I would like to try to answer any questions and just thank you again for this opportunity to share these thoughts and experiences.

[The prepared statement and material submitted for the record of Dr. Jolliff follow:]

Statement of Gary D. Jolliff, Professor of Crop Science
Oregon State University

Before the

U.S. Senate Committee on Agriculture, Nutrition, & Forestry
Subcommittee on Agricultural Research and General Legislation

Hearing on Senate Bill 2413: Agricultural Research
Commercialization Act of 1988

Washington, D.C.
June 6, 1988

Mr. Chairman, members of the Subcommittee, my name is Gary Jolliff. I am both honored and pleased to be invited to come before you as a crop scientist to comment on S2413, the "Agricultural Research Commercialization Act of 1988".

I have been employed by five different state agricultural and land-grant universities consecutively for over 25 years.

I was raised in a rural Ohio farming community and have lived also in Kentucky, Colorado, Colombia, South America, Texas, and Oregon. I have been involved in crop production or crop production research for more than 30 years. During the past nine years I have been the leader of the New-Crops Research Project in the Oregon Agricultural Experiment Station at Oregon State University. During this period my research emphasis has been on the improvement of meadowfoam (Limnanthes) as a new industrial oilseed crop. Meadowfoam is a wildflower native to the Pacific Coast states. It was discovered by the USDA thirty years ago as a seed oil source of long chain fatty acids with unique composition. Beyond the discovery, USDA made no organized provision for the domestication and improvement of this plant as a profitable new crop.

It was of special interest in Oregon because it is adapted to poorly drained soils currently suitable only for the production of certain grass seed crops which require open field burning of residues. Meadowfoam residues do not require burning. Thus, the motivation for meadowfoam development in Oregon was substantially crisis-based. The history of this development is described in more detail in printed materials submitted for the record.

Unfortunately, the historical approach to new crop development in the U.S. has similarly been substantially crisis-based. It is policy by default, a short-sighted or nonstrategy that is haphazard, very expensive, and attentive only to commodities necessitated by the historical moment. This is further emphasized by the submitted summary statement concerning Mr. Wheeler McMillen, a distinguished agriculturalist, who saw the chronic nature of commodity surpluses more than 50 years ago, and tried to spark national interest in expanded industrial uses of farm products. His movement was partially successful when an amendment to the 1938 Agricultural Adjustment Act included $4 million to construct four regional U.S. Department of Agriculture research laboratories to investigate new uses for farm products. Unfortunately, no institutional structure was put into place to domesticate new crop plants and improve them to a state of economic competitiveness. That gap still exists today, and is the focus of my concern.

The unique composition of the oil in meadowfoam was discovered by chemists at the Northern Regional Research Laboratory, Peoria, IL. But, 30 years has elapsed and USDA has taken virtually no initiative to develop this plant as an economic crop.

As a result of my concern for the low priority given to funding new crops research in the U.S., the Council for Agricultural Science and Technology (CAST) asked me to participate on a task force which responded to the October 1983 request from Senator Roger W. Jepsen, Joint Economic Committee of Congress for an evaluation of the needs for, and potentials of, new-crops research and development. CAST Report No. 102 entitled: New Crop Development: Needs, Procedures, Strategies, and Options, was presented in Congressional hearings in October, 1984. The CAST Task Force found that most new-crop development was significantly hindered by the lack of a forceful and persistent voice to speak for support of the research and development needs.

I participated in the Challenge Forum convened by Secretary of Agriculture John Block, October, 1984, to explore new directions for agricultural products and markets; and, subsequently I served as a member of the New Farm and Forest Products Task Force (1984-1987) which reported to this subcommittee in June 1987. Again, it was found by the New Farm and Forest Products Task Force that the greatest single barrier to new-crop development is the lack of a forceful, enduring, and accountable voice for new-crop development to facilitate necessary long-term high-risk multidisciplinary research, development, and commercialization. Such an effort will require vigorous leadership, innovative policies, and tough management.

History proves that entities without political representation typically do not receive attention. New crops, almost by definition, do not have political representation. The USDA has not adequately represented new crops. Perhaps it has been unrealistic to expect the USDA to be a sufficiently firm and persistent voice for new crops when large numbers of special interest groups from existing commodities keep the USDA occupied and accountable for what they consider to be equitable distribution of scarce research funds.

Mr. Chairman, in the interest of time, I make reference for the record to the oral and written testimonies which I presented to your subcommittee June 26, 1987 during hearings on NEW USES FOR FARM AND FOREST PRODUCTS (S. HRG. 100-471 pages 221-329 and 335-344). Those materials list approximately 100 literature references.

Mr. Chairman, the language of S2413 seems to effectively address the aspect of commercialization of those products or ideas which qualify for economic competitiveness in the short term. I imagine that there are significant advances which can be made in this arena. I believe that the Agricultural Research Commercialization Corporation would be a timely vehicle for advancing the commercialization of meadowfoam. It seems especially noteworthy that the Bill requires joint funding of ventures. This partnership should facilitate a very valuable element of local and regional accountability and monitoring. I also favor the integrated review team concept at the regional level. It may, however, be very challenging to find the ideal blend of compatible reviewers and Board members.

That is the good news. Now I will focus attention on what I believe to be a missing element which I judge to be the most critical aspect for the future of the nation's agricultural industry. In my judgement, further provision needs to be made for funding research on new crops as a vital aspect of diversification of American Agriculture. S2413 does not allow for the funding of research on new crops. Thus, there is a serious gap in the mechanism needed for future utilization of the excess production capacity of U.S. agriculture. Research to improve the productivity, and thus the economic competitiveness of new crops is absolutely essential for the diversification of U.S. agriculture. The record shows that it is not realistic to expect USDA, under current organizational structure, to fund new-crop research at levels, and for durations, needed by this nation. Later I will discuss this further.

New crops must be a part of an effective agricultural diversification process. Those new crops will become economically competitive through productivity research as has been done historically with the surplus commodities. It is easy to understand why funds from The Agricultural Research Commercialization Corporation would not be used for further productivity research on commodities in surplus; however, productivity research on new crops such as meadowfoam is equally critical as the need for oil utilization and commercialization research. Currently, for example, the greatest prospects for increased market development of meadowfoam come from increased oil yields of new varieties being developed. Major reductions in price of meadowfoam oil is expected to generate significant market pull. To illustrate the concept, consider, for example, what would happen to the demand for Corvette sportscars if the new car price were reduced to $15,000. The single greatest threat to the future of meadowfoam development currently appears to be the vulnerability of research funding (existing and proposed) to local, state, and national politics. As has been the case for new crops historically, some of the most significant barriers to funding are internal, within the existing agro-industrial complex and public bureaucracies.

I am convinced that the most important need for accomplishment of diversification of U.S. agriculture is the establishment of a constituency or advocate for getting the job done. The congressional mandate originally given to USDA to research 'new and valuable plants and seeds' needs to be revisited. I have the distinct impression that even a Secretary of Agriculture would not be able, politically, to allocate sufficient scarce agricultural research resources to support the needed work on new-crop development.

It is for this kind of reason that I believe an institutional innovation, a voice, if you will, or a champion for new-crops is needed. I am reminded of Proverbs 18:17 (New American Standard Version) 'The first to plead his case seems just, until another comes and examines him'. New-crops have had neither a voice to "cross-examine" the traditional use of funds in agriculture as a matter of accountability, nor the opportunity to plead the case for new crops in their own right. A federally legislated voice for new-crop development could serve both of these roles. It is needed to make wise use of research dollars in development of new crops. To achieve the results needed to revitalize U.S. agriculture through diversification, that voice must be forceful, enduring, and accountable, while being substantially insulated from the short-term political pressures which would stifle and threaten long-term high-risk multidisciplinary research, development, and commercialization.

In my judgement, the single most important action which Congress needs to take, is to specifically charge an organizational entity with the responsibility to achieve the goal of diversification of American agriculture. This recommendation was the cornerstone of the actionable proposal presented in June 1987 to the Secretary, United States Department of Agriculture, and to this Subcommittee by the New Farm and Forest Products Task Force.

The organizational entity which receives the 'diversification charge' from Congress must have the institutional structure, resources, accountability, and continuity over several decades to accomplish the needed task.

The kinds of change needed for accomplishing U.S. agricultural diversification will not come easily. The kinds of changes recently needed in the U.S. auto industry did not come easily. In fact, it took "life threatening" foreign competition to force the change in the auto industry. I believe that Congress must provide the outside force to cause needed change, to overcome the momentum of the U.S. agricultural industrial complex. The evidence from history suggests to me that Congress may provide the needed external force in the form of an institutional change which will require the investment of research into the development of new crops. I suppose that one possible approach is to require the Agricultural Research Commercialization Corporation to spend at least half of their resources on developmental research of new crops. It is quite clear that the major surplus commodities receive major portions of the present federal agricultural research and development budgets, plus it is appropriate for them to take more leadership in promoting and financing the development of new uses for surplus commodities as is being done by the National Corn Growers Association.

As stated, and documented, in my June 26, 1987 testimony, the USDA has had the mandate, the authorization, the talent, and the resources to develop new crops for more than a century. Yet there is a very limited track record of aggressive leadership and serious investment in new-crop development. This suggests that the USDA institutional structure is not appropriate for this vital, but uncommon task.

Dr. Vernon Ruttan, noted expert on agricultural research policy, states, and I quote: "institutional innovation is both a more powerful and a more reliable instrument of reform than technical change", end of quote. It seems to me that the United States agricultural/industrial complex has, since World War II, ridden the crest of technological change without being forced to consider the timeliness of institutional innovation. I believe that the astronomical cost of the farm programs during the past decade is a mandate to Congress to do whatever is necessary institutionally to gain some accountability for diversifying U.S. Agriculture.

In the decade of 1979 to 1988, the gross level of outlays by the U.S.D.A. Commodity Credit Corporation for commodity price and income support exceeded $270 billion (Source: Stephen Dewhurst, Budget Officer, USDA, Washington, DC). At five percent simple interest, these resources cost an additional $41 billion during that decade alone. These figures do not include the lost profit potential from new crops which could produce commodities of higher value. Based on the calculation I have developed in the manuscript submitted for the record, this $300 billion investment in surplus commodities during the past decade would pay the full 20-year costs of developing somewhere between 357 and 7500 new crops.

Obviously, there are not 7500 plant species which are of high priority for development as new crops. But the point should be clear, we must get USDA busy working on new plant resources, or else find someone else who will do the job.

A sad commentary results from my investigations into the role which USDA has played historically as an aggressive advocate for new crops development. As a general rule, USDA has played the role of a political reactionary rather than that of the nation's visionary. I am not saying that this is necessarily the fault of individual administrators within USDA; it may simply be the system. People typically respond to the reward systems under which they are employed. Nevertheless, it is difficult to find even one case of a new crop (apart from a national crisis) where USDA was the leading force for its development. This would include a long term commitment up front. It would mean hiring the best scientists available, rather than assigning remnant staff, or splitting the assignments of scientists between various crops as is commonly done with new crops research. It also means full staffing, on par with the types of scientists, equipment, support staff, facilities, and services and supplies afforded crops such as cotton, corn, or wheat. At present, USDA has asked one of their scientists to do research on a new crop, and the support provided is a strikingly small fraction of what is published as the amount of resources needed to launch new research efforts. There needs to be more accountability for getting the needed job done. In the manuscript submitted for the record, I have built a justification for investing a minimum of 15 scientist years per year for a minimum of 20 years on the development of a new crop. Based on the standards described in this paragraph, I would speculate that USDA has very few, if any, examples of this type of commitment to new crops in the entire history of the organization.

I desire to be fair with USDA employees. In my opinion, the current institutional structure of USDA makes it politically unlikely that new-crops research will ever become as high a priority as is needed for U.S. Agriculture. The political biases, bureaucracy, and internal reward system accounting for this are briefly described in the June 26, 1987 testimony referenced above. I have personally been involved with this system for several years, and could describe it more specifically.

It seems that the bottom line for Congress is to decide to whom do you listen. By definition, new crops have little, or no constituency. The major agricultural supply and marketing industries can make profits so long as crops are grown. Typically, it doesn't much matter to these firms whether or not the farmer makes a profit. The seeds, herbicides and fertilizers are used, and the commodity is available to ship, store, process, market, etc. These industries, like most in the U.S., thrive on short-term profits. Thus it is in their best interest to earn profits in the short term. New crop development generally does not offer profits in the short term. Thus, new crop development at the expense of existing commodity programs is in conflict with the agro/industrial complex. Typically the agroindustry forces are very well represented on Capitol Hill. And they do their jobs very well. Also, large producers are well represented. Pasour [J. Prod. Agric. 1:64-70 (1988)] has demonstrated that a fundamental change in direction of farm programs is warranted. He shows that the major benefits of farm commodity programs, rationalized as measures to assist low income family farms, accrue to farmers whose incomes, on average, already exceed those of the taxpayers financing the programs.

At the same time, there are no vested interests to speak for the 'unborn' crops which are needed to diversify U.S. agriculture. Furthermore, most of the persons in the agricultural industry, including farmers, scientists, and bureaucrats, do not have experience with or any vision for the development of new crops.

Again and again, I illustrate why the U.S. needs a voice for new-crop development! It seems to me that Congress must legislate a 'vested interest' in new-crop research and development. The rules need to be changed for the way the agricultural game is played. It is in the best interest of the nation.

This is not to say that we should dismantle the best agricultural research and development network in the world. But I am saying that Congress should direct the United States Department of Agriculture, or some other responsible and accountable entity with the charge to achieve the diversification goal, to invest in research to develop new crops, and bring them to economic competitiveness.

The rationale for doing this is developed in a manuscript which I have submitted for the record. It is entitled 'Strategic Planning for New Crop Development'. I have based my calculations and recommendations on the figures used by USDA and the state agricultural experiment stations, and on the history of crop productivity responses to research.

I propose that the United States of America commit to the ongoing development of the 50 most promising new crops. Symbolically, this is one new crop per state. Through carefully selected projects, including joint ventures, commitment levels of at least 15 scientist years per year, fully funded ($150,000 to $225,000 per year; plus start up funding of an additional $150,000 to $425,000 per scientist year) should be allowed and encouraged when justified.

Thank you for the opportunity to share my views on this very important topic.

Material submitted for the hearing record follows:

(May 31, 1988)

Strategic Planning for New Crop Development[1]

Gary D. Jolliff[2]

Submitted to

Production Agriculture Journal

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[1] Contribution from the Dep. of Crop Sci., Oregon State Univ., Corvallis, OR 97331. Oregon Agric. Exp. Stn. Tech. Paper No. 8421. Received

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SUMMARY

The high cost of chronic agricultural commodities surpluses justifies immediate national attention to strategic planning and the development of new crops. The need is urgent to diversify the crop-plant base from which the U.S. generates its annually renewable wealth. The technological tools and plant resources are available, but as yet, neither federal appropriations nor a Congressionally authorized management entity has been forthcoming. The Foundation for New Farm and Forest Products has been proposed as an essential institutional change for orderly development and commercialization of profitable new crops to diversify U.S. agriculture.

INTRODUCTION

The U.S. government has spent more than $200 billion over the last ten years on domestic programs related to surplus agricultural commodities (Fig. 1) (5) (S. Dewhurst, U.S.D.A. Budget Officer, personal Communication). These multi-billion dollar outlays in such things as commodity price supports, export programs and farm credit bailouts, together with record numbers of farm bankruptcies, all suggest a policy-stimulated over-concentration of U.S. agriculture on a few primary commodities.

Excess production capacity abroad has aggravated the problem. Wheat production in Bangladesh, for example, increased tenfold between 1971 and 1981 (7); and U.S. agricultural exports to China dropped precipitously between 1981 and 1986 as that country's agricultural output increased (35). The Director of the Illinois Agricultural Experiment Station, Dr. Donald Holt, recently cautioned, "We may be in danger of underestimating the ability of other nations to develop and apply agricultural technology effectively. For over a hundred years we have had little competition from the primitive agriculture of much of the world. That situation is rapidly changing."

The biotechnology industry has, somewhat paradoxically, contributed to the problem as well--as agricultural production techniques become more efficient, commodities surpluses increase further. One biotechnological product, for example, enhances animal protein production, thereby reducing the quantity of feed required to market livestock. The projected decrease in feed demand would add an estimated 3.4 to 10 million acres of excess crop production to U.S.

agriculture (26), expanding excess crop production capacity--already estimated (54) at 40 million acres--by 9 to 25%.

The use of biotechnological methods in agriculture is somewhat analogous to the employment of robotics operations in manufacturing. While improved manufacturing efficiency may be large, total national health and economy could experience severe impacts from labor displacement and insufficient alternatives for productive re-employment. The solution, for both industry and agriculture, lies in diverting resources into new, more productive sectors. In much the same way that displaced workers have been retrained, sufficient investment to appropriately develop new crops can help convert the excess U.S. agricultural production capacity from a liability to an asset.

As existing federal policies have stimulated overproduction, so new policy directions are needed to help insure competitiveness of U.S. agriculture in the commodity markets of an increasingly self-sufficient and productive world. While agriculture is the largest single contributor to the U.S. economy and arguably a very efficient industry (31), given the chronic nature of surpluses, scientific production of only the major crops may no longer be enough. Farming constituted only 11.3 percent of the agricultural sector contribution to GNP in 1982 (39). But new industrial crops and products could very well cycle within the domestic economy, generating GNP at rates equal to or greater than GNP generation by subsidized commodities currently produced in surplus and exported with little, or no, value added. Successful competition in today's world market requires a renewed attentiveness to one of the original Congressional mandates to the USDA: to research "new and valuable plants and seeds" (48).

In spite of this clear mandate, historically, powerful vested coalitions and diverse individual attitudes have limited the nation's capacity to reallocate scarce public funds within agriculture, or to acquire new funding for research and development of new farm and forest products (45).

After the agricultural commodity surplus crisis of the 1950's, a modest infrastructure for new-crops research was developed within the U.S. Department of Agriculture (27). Redirection of new-crops funding to other research areas, however, drastically dismantled this program during the few years when dominant crops yielded encouraging profits (58). Such political vulnerability must be avoided through appropriate program innovation and strategic planning. Currently, no voice exists which can appropriately represent the long-term interests of U.S. farmers through support of high-risk ventures in the development of new crops. Congressional action will be required to bring about needed institutional changes, and like federal budget deficit reduction summitry, efforts will require keen statesmanship.

Various analysts have suggested an interdisciplinary approach in creating and operating such institutions (3, 18, 33). Specialists are needed for germplasm collection, genetics, breeding, agronomy, physiology, pest management, crop modeling, processing, utilization, economics, and marketing. Institutional models for this type of multidisciplinary effort do exist. A cooperative approach at the International Rice Research Institute has, in 25 years, yielded gains in world rice improvement that compare favorably with total advances realized during the previous 5000 years (22). The rate of crop improvement progress in highly domesticated plants such as rice only underscores the potential for developing other plants as new crops.

While the U.S. has demonstratively lacked a national organizational focus in new-crop development in recent decades, the dramatic improvements in both established crops and in crops expanded in the U.S. during the past half century (soybeans, safflower, sunflower, grain sorghum, kiwi, jojoba, wild rice) indicate the substantial gains possible from new-crop development efforts (24, 27, 34). "The greatest service which can be rendered any country," Thomas Jefferson observed, "is to add a useful plant to its culture" (12).

NEW FARM PRODUCTS

What constitutes "usefulness" has broadened considerably since Jefferson's time. Today, consumer needs that could be met through the utilization of U.S. agricultural resources include plastics, cosmetics, gasoline and lubricant additives, insecticides, medicines, paper products, super absorbent polymers, and foods low in fat and cholesterol (27, 42, 44, 49, 53). In addition to substantial economic benefits, new crop development could address a wide variety of environmental concerns. For example, health hazards could be reduced by using vegetable oil to replace petroleum-based plasticizers in industry; plant-derived lubricants that substitute for sperm whale oil could be developed; ethanol from biomass could be used as a fuel to reduce urban lead levels and control atmospheric carbon levels; and perennial crops could replace annual crops on highly erodable land (24, 27, 37, 53).

Moreover, many strategic and essential substances or plant-derived substitutes could be grown in the U.S. Where natural rubber, castor oil, and sperm whale oil must be stockpiled for defense purposes (53), domestic production of new crop candidates--such as guayule to supply natural rubber, and jojoba as a source of liquid wax esters--would help insure availability of these strategic materials (24, 42). Furthermore, new crops could supply essential industrial materials--waxes, resins, gums, newsprint, lubricants, and alternative sources of hydrocarbons used in manufacturing numerous synthetics (49, 53). But the greatest area of opportunity for new agricultural products lies in applications which do not substitute for, or compete with, current agricultural products, but do create totally new markets. Meadowfoam, a new source of unique long-chain fatty acids, is a case in point (44, 56).

Indeed, increased efficiency of producing resources, such as using potentially lower cost high fructose sweeteners from corn to replace cane and beet sugar, could benefit society. But, such change could also dramatically reduce sugar crop acreage and spell disaster for cane and beet sugar growers. Thus, strategic planning and a national-level long-term commitment to buffer the effects of such crop acreage displacement by introducing new replacement crops are clearly justified.

Soybean introduction and commercialization on 40 to 60 million acres of corn, wheat, and cotton land in the U.S. (27) is illustrative in this respect. Though interest in soybean as an oilseed crop in the U.S. was highly limited in the early 1900's, the crisis of domestic vegetable oil shortages during WWI drove up the price per bushel of soybean in 1920 to more than $4.00 (24). Both the crisis-born profit potential and the strong, enduring, and accountable voice of W. J. Morse, director of soybean research in the USDA, transformed soybean into a "Cinderella" crop. In 60 years since 1925, soybean had a total, inflation-adjusted, farm-gate cash value of $188 billion (2, 51). The larger benefit to the nation's economy, assuming a 2.75-fold multiplier to estimate economic activity (10), is estimated at $518 billion. This "miracle crop" too is now becoming one of the surplus commodities in some U.S. farming regions; as soybean prices decline through domestic overproduction and foreign competition, thousands of farmers in certain regions, having no profitable alternative crops, become trapped.

The history of soybean production has a threefold significance: it illustrates the potential economic significance latent in experimental crops; it underscores the role of a strong political voice in directing public resources to crop development; and it points to the crucial necessity of an ongoing, long-term commitment to new-crop research that can forestall future cycles of agricultural overproduction.

ECONOMIC PAYOFFS

What is the potential for the development of new crops into profitable alternatives? While new farm and forest products should not be viewed as a quick or complete solution to the problems of surplus agricultural commodities, there are substantial grounds for optimism. The historical development of two major, long-domesticated U.S. crops--corn and soybeans--provides suggestive models of how plant productivity can be increased to benefit society. During the 20th century, average U.S. yields of corn and soybean increased by 300% (Figures 2 and 3) (51), with about half of this increase owing to plant-breeding efforts alone (6, 8, 16, 38). At the same time, the labor required to produce corn in the U.S. in 1986 was approximately one-fiftieth of that needed in 1910 (51).

Similar types of efficiency--and even higher rates of yield improvement--could be expected as successful alternate crops and products are developed. Yield improvements in particular are a critical first step in making new crops profitable and promoting positive attitudes and support for sustained research and development. To take but one example, a socioeconomic analysis of costs and benefits of a 14-year investment made by Canada in improved rapeseed (Canola) varieties and crop development estimated a 101% annual net return to society, with benefits divided about equally between producers and consumers (32). Successful investments in new crop development substantially serve producers through improved income, consumers through lower cost and higher value commodities, and investors through added national wealth (14).

INVESTMENT LEVELS NEEDED

There is a desperate need for realistic expectations from research on new crops, and for corresponding support levels--an approach that would be aided by developing and using, as a guide, accurate historical timetables and investment levels for the improvement of established crops. Low levels of investment in new-crop research have been common and have led to long-lasting disappointments. An estimated 3000 to 6000 scientist years of publicly funded support have been invested in corn and soybean over the period 1920-1985, during which the crops' yield increased 300% (52). A scientist year (SY) is the total direct costs plus indirect costs of a full-time scientist, support staff, supplies and services, and equipment for 12 months. Currently, corn and soybean receive over 300 scientist years of public research; wheat and cotton about the same (Fig. 4) (52). The total annual cost per scientist year of a well-funded program currently ranges from $150,000 to 225,000 (1, 15, 30, 47, 52); with start-up cost averaging $453,000 per year of additional funding for facilities and equipment according to a 1986 national planning document (15). Public funded projects on new crops seldom get average or better funding for continuing or start-up costs. In current dollars, the average total public funded research cost to increase yields by approximately 300% would be an estimated $840 million. This is based on the average number (4,500) of scientist years invested per crop in major crops (cotton, corn, wheat and soybean) during a period of 300% increase in yield, multiplied by the average scientist year cost of $187,000. New crops such as meadowfoam (Limnanthes ssp. Benth.) have been developed for a much smaller investment than has been afforded these major crops, and current technology would allow for accelerated rates of improvement and commercialization. Nevertheless, these major-crop calculations help provide a basis for investment levels needed in, and expectations from, new-crop development. It is important to note as well, that investments far beyond the public sector have contributed to the development of crops such as corn, soybean, wheat and cotton. Evenson (13) calculated that private funding of U.S. agricultural research in 1979 was 1.5 times more than public funding. Scientists at state and private colleges and universities conduct significant basic research on major U.S. crop plants funded by sources such as the National Science Foundation, the Department of Energy, and NASA, facts not included in the tabulations above. Furthermore, in the case of most major surplus crops, hundreds of additional scientist-years are invested annually by research and development organizations and universities outside the U.S.

Therefore, 10-20 public-funded scientist years per year, or approximately $2-4 million, focused on a specific high priority new crop appears to be a highly conservative minimum investment for a plant which has not yet attracted private research and development interest. Moreover, the support must be dependable, allowing scientists to commit to necessary long-term crop improvement projects. Over a twenty-year minimum development period, this minimal level of public funding would total $40-80 million. By contrast, less than $6 million has been invested during the initial 20 years of meadowfoam domestication and commercialization effort in the State of Oregon.

CHALLENGES FOR LEADERSHIP

The high-risk, long-term nature of new crop development, and the fear of the unknown, seriously hinder policy-makers from standing alone in support of such an effort. Solutions to the seemingly exotic and complex problems in new crop development may appear costly compared to well-established commercial crops; however, opportunities for potentially large advances also are present. Recently the oil yield per acre of meadowfoam (*Limnanthes spp.*) in Oregon was increased 50 percent over an 8-year period at a cost of less than $1.0 million; and in a separate instance (40) severe seed shattering in *Vernonia* was overcome by one germplasm acquisition. Since the yield potential of new crops generally is undeveloped, dramatic yield increases may be possible within a relatively short time.

But realizing such increases requires a national policy--one with a clear legislative direction, authorization, and appropriation that will give organization and stability to alternative crop development. The U.S. particularly needs a mechanism to overcome the entry barrier hindering new crop development. In the early stages of crop development, long-term funding is difficult to maintain. Private industry typically is not interested in funding this type of research until the profit potential is apparent. By the same token, unrealistic expectation from new crops is a problem that can result in a defeatist attitude which affects support for other research projects. And scientists themselves are often reluctant to risk investing time in new, uncertain crops, preferring the security of an established crop with existing scientific, financial, and political support organizations. The entry barrier to development is a type of new-crop catch 22: funding is not provided until profit potential is demonstrated, which cannot be done without funding the research.

Too often new crops are expected to be profitable before appreciable developmental research has occurred to increase the yield. Thus, economic analyses of yields of wild plants or unadapted alternate crop cultivars have resulted in unimpressive prospects. Historically, major crops--even those domesticated for millenia--have increased in yield by over 300% during the 20th century given sufficient research investment. Therefore, estimates of future yield and profit potential--and setting of research investment for a given new crop--could appropriately be based on yields at least 300% higher than those experienced upon initial domestication or selection. Added indirect benefits from new crops, such as improved pest control through crop rotation, should be measured and credited to the new crop. Furthermore, a dramatic reduction in costs of producing, harvesting, processing, and marketing can be expected with systems research and engineering developments. And, finally, new crop profit potential should be measured against traditional crops minus crop subsidies and other distorting influences.

If past-crop developments provide an index for new-crop yields, they serve as well to emphasize the importance of making long-term commitments. Approximately 200 years elapsed from the time soybean was introduced in North America (20) until it was established as one of the five major field crops. Approximately 80 years were required to move the concept of hybrid corn from hypothesis to widespread use (28); and most of a century elapsed from the time Daruma-type dwarf wheats were first reported in Japan until the dwarf genes were extensively used in high-yielding U.S. cultivars (41). While biotechnology may offer opportunities for new-crop development at an accelerated pace, traditional plant breeding and agronomic research will be crucial to improvement efforts (6, 8, 16, 27, 38). Thus, based on historical timetables for crop improvements, a philosophy and mechanism allowing for a minimum 20-year commitment to improvement of a given new crop is needed.

But in the U.S., nothing less than a national shortage of a commodity and the concerted long-term efforts of an individual or an organization to champion a new crop have been necessary to successfully launch an integrated new crop development strategy at the national level, as is illustrated by the histories of soybean and rapeseed development (17, 27, 57). This crisis-based policy is policy by default, a short-sighted or nonstrategy that is haphazard, very expensive, and attentive only to commodities necessitated by the historical moment.

Congress, however, could lead the way toward a solution by legislative policies that would ease the problem of overcoming the multifaceted entry barrier--paving the way for aggressive, sustained private-sector investment by using, quite literally, the "seed money" of public funding. To justify the use of public funds for improving the profit potential of new crops, a comparison can be made between crop development costs and the costs of surplus commodity programs. The estimated costs associated with research and surpluses during the decade of the 1980s have been used. The cost of improving a new crop, based on precedents, can be estimated at $40 to $840 million. The $12 billion cost to the U.S. government in one year for the 1987 corn-related support programs would therefore be equivalent to the estimated total 20-year cost for improvement of 14 to 300 new crops. The $~~170~~ 200 billion spent on farm income stabilization during the decade 1978-1987 would fund the total 20-year costs of improving 238-5000 new crops. Though there are not 5000 high-priority plants to develop as crops, the figures dramatize the staggering disproportion of expenditure.

Funding is a necessary condition, but not a guarantee of sufficient condition for the successful commercialization of a given new crop or new product. However, experience suggests that potential crops chosen carefully could be expected, at least corporately, to return wealth to the nation in a manner similar to the $518 billion earned by soybean in 60 years. Less than 1 million acres each of 50 new crops (symbolically, one per state) could absorb the current domestic excess production capacity. Funding each of 50 new crops at the annual rate of 15 scientist years would cost $140 million--approximately 18% of the U.S.D.A. budget for the Agricultural Research Service (ARS) in 1987, or 7-9% of the combined ARS plus individual state appropriations (1987) or 0.27% of the $50.618 billion 1987 gross level farm income stabilization costs (S. Dewhurst, U.S.D.A. Budget Officer, personal communication).

Contrasting approaches to public funding of crop improvement are revealed by comparing the relative amount invested in soybean development by the U.S., with the resources devoted to rapeseed improvement in Canada. In 1952, the U.S. had the equivalent of 7.3 public geneticist plus plant breeder scientist-years working on soybeans (25) while the U.S. produced $750 million worth of crop (2, 51), a ratio of 0.0097 geneticists plus plant breeders per million dollars of crop value. Over the same time period Canada invested in 1.43 geneticist plus plant breeder scientist years per million dollars worth of rapeseed production (47). The Canadian rapeseed development project risked investment at a rate 147 times greater than the U.S. investment in soybean development. The Canadian effort was planned, focused, and coordinated among farmers, industry, government (both federal and provincial), and academia. Today Canada leads the world in edible rapeseed oil exports.

Agricultural research expenditures in Western Europe were similar to those in North America in 1950, but became twice as high by 1980 (50). The current extent and aggressiveness of the national new-crops research and development focus in the Netherlands reflect strategic planning plus action. Worldwide expenditures for public agricultural research increased by 360 percent, after inflation, between 1959 and 1983 (50). During this period North America's share dropped from 32 percent of world expenditures to 18% (50). Several competitors in the world agricultural commodities markets have developed highly successful strategies for agricultural technology import and transfer. These strategies have caused U.S. farmers to steadily lose the competitive advantage they had once gained from early adoption of new technology (50).

The U.S. reactive approach to crop research support is illustrated by increased investment only after crop production increased (e.g., soybean, Fig. 5; sunflower, Fig. 6). By contrast, Canadian investment in rapeseed development, as described above, demonstrates a strategy and a relatively higher research investment before crop production was large (Fig. 7). As the records of soybean, rapeseed, and sunflower bear out (16, 27, 32, 47) a relatively high level of initial public investment in research on an appropriate new crop can increase chances, and rate of, success and profitability.

WHY A NEW ORGANIZATIONAL ENTITY?

Granting that the need exists now for new-crop development, and that it will become even more urgent with improved farming efficiency worldwide, the question arises how to most effectively implement research and development on new and alternative crops and products. The private sector cannot be expected to undertake the long-term initial investments needed for new-crop development; a steady public support source is fundamental. The well documented (27, 46) unstable nature of public investment in identifying and developing new crops and new products illustrates the critical economic need for strategic planning in U.S. agriculture. Moreover, with exit of the fossil fuel age, it is appropriate to focus national attention on satisfying future consumer and industrial needs from agriculture. Conditions, events, and societies support modifying the "agriculture-food" stereotype to include expanded production of nonfood industrial raw materials.

An ongoing entity--a foundation, institute, center or association--has been called for (27, 34, 46), and Erich Bloch, Director of the National Science Foundation, has described many elements of change needed to foster a national research strategy to rebuild U.S. economic competitiveness (3). The need for new crops could be a rallying point, but, as Bloch points out, making the proposed institutional change will require "tough management, innovative policies, and vigorous leadership" (4).

The importance of a well-qualified and unbiased organization involved in objectively choosing and promoting the most promising new crops can be seen from the structural bias in the political funding process (18). Funding of agricultural research by the public sector overwhelmingly reflects the interests of producers, handlers, and processors of established commodities and technological areas of topical interest (e.g., genetic engineering and biotechnology) (19, 29). The need exists for a forceful and enduring voice for research into new farm and forest commodities (34, 46). While interest at present is high in new technologies, such as genetic-manipulation tools applied to agricultural research (29), Vietmeyer cautions against emphasizing technology at the expense of promoting development of renewable sources of wealth such as a new crop (55). Likewise, Ruttan has pointed out that "institutional innovation is both a more powerful and a more reliable instrument of reform than technical change" (43).

An entity responsible for new-crop development would provide the means to develop a strategy, to focus new technology on exploiting renewable wealth from plants, and to solve problems that often prevent their domestication. It could attract scientific talent, leverage resources to priority crops, and promote a collective synergy among diverse interest groups (23). The development of new crops and products could take place largely within existing agricultural research networks. Action of this nature is being taken at the state level through the Greater Minnesota Corporation, and by the University of Minnesota Center for Alternative Crops and Products. A New Farm and Forest Products Working Group has been formed at the University of Missouri, and they cooperate with Missouri Ingenuity, Inc. which is a venture assist corporation.

The track record of crop improvement research by agencies focusing on specific crops has been highly successful to date. The development of the Canadian rapeseed industry as supported by the Saskatchewan Wheat Pool (57), and improved potato germplasm produced by the International Potato Center and used by over 80 countries (21) attest to the progress possible with long-term support focused on particular crop plants. The other International Agricultural Research Centers (9), particularly the International Rice Research Institute (22), has made remarkable progress in crop improvement. More than 1000 new crop varieties had been developed at these centers by 1983. The modern rice and wheat varieties developed at these centers annually yield enough more than the old varieties would have produced to feed an additional 500 million people (9). Ironically, while the U.S. has participated in the planning, development, and support of most of these international centers, it has not established any comparable comprehensive interdisciplinary effort for domestic development and commercialization of new crop-plant resources.

PROPOSED FOUNDATION FOR NEW FARM AND FOREST PRODUCTS

Multidisciplinary needs in new crop development argue for creating a stable, organized entity to foster cooperative efforts. Bloch (3) recently targeted the need for increased emphasis on centers or institutes to promote interdisciplinary research for the purpose of addressing today's complex and challenging problems. The establishment of entities to coordinate research efforts and to focus on vital, multidisciplinary areas has been identified as essential to U.S. economic health. Recent proposals to develop 80-100 science and technology centers at U.S. universities by 1992 (36), create a "National Institute of Technology", and establish an "Advanced Civilian Technology Agency" (11) reflect the growing awareness of the need for federal action to increase U.S. economic competitiveness.

A New Farm and Forest Products Task Force was formed in 1985 to address the potential of diversification in U.S. agriculture and forestry (34). The task force was an industry-led cooperative effort that included government and academia. One of its initiatives was a proposal for establishing an organizational entity that would promote the development of alternative products from farms and forests. On June 25, 1987, the New Farm and Forest Products Task Force recommended to the Secretary, U.S. Department of Agriculture, the formation of a Foundation for New Farm and Forest Products (NFFP). On June 26, 1987 a hearing was held before the Subcommittee on Agricultural Research and

General Legislation of the Committee on Agriculture, Nutrition, and Forestry, United States Senate to report as a Task Force and investigate how to raise farm income by commercializing new farm and forest products. "The proposed organization would be an autonomous, non-profit corporate entity with a mission to foster and facilitate the development and commercialization of new farm and forest products. As conceptualized, the Foundation would be specifically charged with the responsibility to achieve the diversification goal. Bridging both private and public sectors, the Foundation would serve as an advocate, catalyst, coordinator, and cooperative funding source for the development of new farm and forest products." (34) It could also nurture user, grower, and processor groups for individual crops or products and thus greatly decrease the time required for such necessary groups to organize and operate effectively.

Given the sensitivities involved, extreme care will be required to develop the organizational blueprint to accommodate the diverse nature of potential projects and participants. Trust funds would be used to foster and sustain collaborative initiatives (joint ventures and matching funds) between the private and public sectors. With ebbing total federal and state funding of agricultural research (Fig. 1), an adequate source of funds for such an organizational entity is difficult to envision apart from special legislation such as that proposed for trust funds (34) to be repaid in the future.

This Foundation could provide cooperation with established commodity organizations and mobilize research technologies. It could institutionalize a strategic plan for competitiveness and diversification in U.S. agriculture. Establishing a Foundation for New Farm and Forest

Products could provide needed balance to development and commercialization of crops to benefit the U.S. It is conceivable that Congress would favor increased total funding of agricultural research and development based on strategic plans for commodity production substantially beyond those traditionally in surplus.

CONCLUSION

Technology exists to exploit the economic potential of new crops as annually renewable alternatives to chronic expenditures on surpluses. The national challenge is to focus sufficient public resources on a prudent number of new crops to make them profitable, without subsidies, for production on U.S. farms. Thus, an orderly development of botanical resources is needed to overcome entry barriers and to maximize successes of efforts to develop new farm and forest products. To achieve this goal, an organized national commitment, with responsible institutional structure, resources, accountability, and continuity over several decades, is essential.

As Block has observed, "New roles for institutions, and more cooperative and innovative relationships among them, will require alteration of some deeply ingrained political attitudes" (4, p. 27). It is time for Congress to act.

APPRECIATION

Much of this research was done as part of the New Farm and Forest Products Task Force Report to the Secretary, U.S. Dept. of Agric.; R. L. Sampson, Chairman. Appreciation is expressed to the numerous colleagues and administrators who assisted in the review process.

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Figure 1. Federal outlays for farm income stabilization, and for research in the U.S. Dept. of Agriculture. Budget of the U.S. Gov't., Function 351 is farm income stabilization. U.S. Dept. of Agric. research is Function 352 minus services (1974-87). For 1984, the $9.7 billion value of the Payment-In-Kind commodity program (W. Bourley, OMB, personal communication) was added to the $11.9 billion outlay under budget function 351. Costs from the Commodity Credit Corporation, Farmers Home Administration and PL-480 for 1985, 1986 and 1987 have been included even if not accounted for until the 1988 and 1989 federal budgets.

Figure 2. Corn yields in the U.S. From: J. Prod. Agric. 1:84. (51). Sources: National ten-year averages were derived from USDA Agric. Statistics (1936, 1945, 1965, 1985). Highest county averages are from U.S. Census of Agric. Summary Data for the closest available years (1924, 1939, 1959, 1965, 1985). Highest corn yield on record (farmer's field) from W. Nelson and H. Reetz, Crop and Soils 38, 5-7 (1986).

Figure 3. Soybean yields in the U.S. (51). Sources: National ten-year averages were derived from USDA Agric. Statistics (1936, 1945, 1965, 1985). Highest county averages are from U.S. Census of Agric. Summary Data for the closest available years (1924, 1939, 1959, 1965, 1985). Highest soybean yield (research plots) on record from: R. Flannery, Better Crops with Plant Food (Winter, 1983-84) pp. 6-7.

Figure 4. Total public sector (U.S.D.A. plus State Agric. Expt.

Station) funding invested in cotton, corn, wheat, and soybean (52).

Figure 5. Soybean production and public sector funding of soybean genetics and plant breeding in the U.S. (25, 51).

Figure 6. Sunflower production and public sector funding of sunflower research (51, 52).

Figure 7. Canola production and public sector funding of canola genetics and plant breeding in Canada (32).

Fig. 1

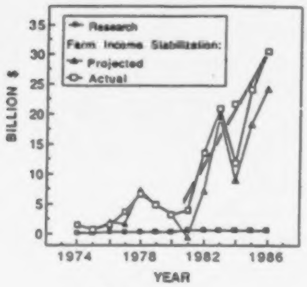
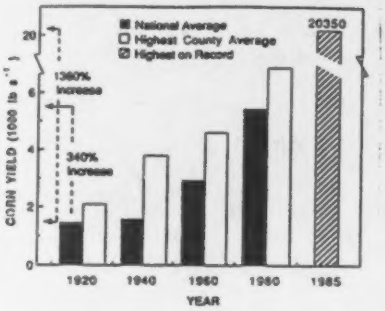


Fig. 2



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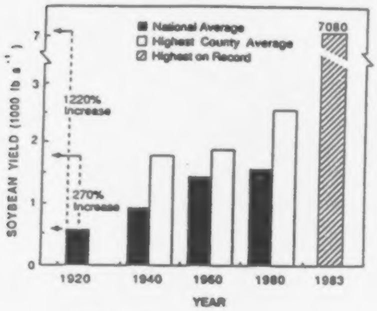

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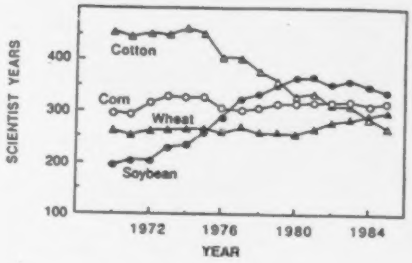


Fig. 5

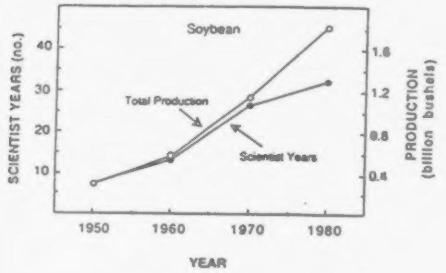


Fig. 6

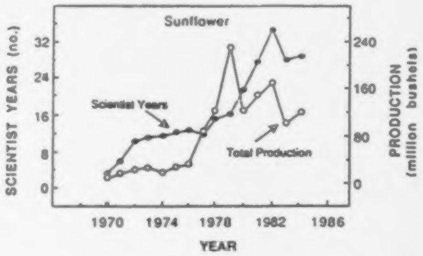
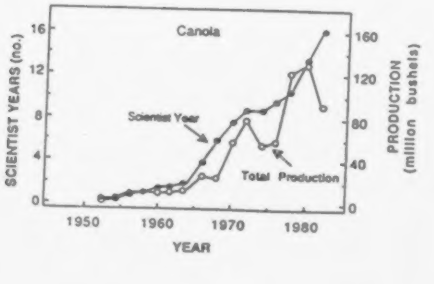


Fig. 7



ANALYSIS OF TRUE COST OF COMMODITY PRICE AND INCOME SUPPORT PROGRAMS, 1978-87, by DR. GARY D. JOLLIFF

Gross and Net Outlays of U.S.D.A. Commodity Credit Corporation for Commodity Price and Income Support Programs, 1978-87. (Source: Stephen Dewhurst, Budget Officer, U.S.D.A., Washington, D.C.)

Year	Gross Level of Support	Interest Costs (@5% Simple)			Total Gross + Interest	Net Support	Gross w/o PIK & w/o Certificate
	Billion $	Billion $ @ 5%	x Years	= Billion $	Billion $	Billion $	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1978	11.840	0.5920	x 9	= 5.328	17.168	5.623	
1979	9.913	0.4956	x 8	= 3.965	13.878	3.572	
1980	10.232	0.5116	x 7	= 3.581	13.813	2.717	
1981	11.933	0.5966	x 6	= 3.580	15.513	3.994	
1982	17.468	0.8734	x 5	= 4.367	21.835	11.598	
1983	32.246	1.6123	x 4	= 6.449	38.695	18.757	27.280
1984	27.598	1.3799	x 3	= 4.140	31.738	7.183	13.914
1985	25.222	1.2611	x 2	= 2.522	27.744	17.574	24.271
1986	36.528	1.8264	x 1	= 1.826	38.354	25.718	31.943
1987	50.618				50.618	22.256	30.859
Totals	233.598			35.758	269.356	118.992	
1988	48.829				17.532	25.084	
1989	36.866				17.013	22.484	

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New Crop Development: Opportunity and Challenges

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The development of new, profitable crops for U.S. agriculture would address: 1) the challenge to produce more marketable products using lower inputs and under harsh conditions; 2) the continuing crisis of crop surpluses; 3) the unstable economic situation facing growers; and 4) the unfavorable balance of trade. Available new crops that hold promise include oil-producing, wild plant species; ancient food crops of the Inca empire, and high fiber crops for pulp production. In contrast to the promise inherent in potential crop species, efforts to develop new crops have been intermittent. We will explore the challenges facing new crop development through discussion of a decision-matrix approach to problem identification. Our experience with meadowfoam, a new agronomic plant, illustrates critical stages in new crop development. Analysis of Canadian rapeseed and U.S. soybean development rounds out a discussion of successful approaches in new crop development. The need for alternatives to overproduced crops has never been greater. A new era in agriculture is possible, based on the comprehensive development of our genetic plant resources; however, it will not arrive without substantial investment in new crop development.

Additional index words: **Alternative crops, Special crops, Industrial crops, Future crop development, Agricultural research policy, Agricultural diversification, Strategic materials.**

New crops have been the foundation of U.S. agriculture. Early colonial farmers were experimenters, evaluating and selecting among crops from the Old World and the New. The development of wheat production is illustrative of this process. Wheat was new to North America at the beginning of the colonial period, yet it quickly became the primary commercial crop of the middle colonies (21). Consumers around the world are indebted to such crop pioneers as the first Midwestern corn growers, and the developers of soybean from insignificance into today's multi-billion-dollar agribusiness (G.D. Jolliff, 1986, unpublished data). The resounding success of the U.S. productive capacity for such crops as corn, wheat, and cotton is underscored by the devastating economic impact of current overproduction. The development of alternatives to overproduced crops would not provide instant solutions to current economic ills. However, we contend that the future holds opportunity for innovative policy makers, researchers, developers, and producers of new crops (G.D. Jolliff, 1986, unpublished data; 28).

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Modern agriculture is based on a limited number of crops. Less than 20 crop species provide over 90% of the world's food (28, 31). Dependence on relatively few crop species increases the vulnerability of producers to environmental and economic fluctuations. The expansion of available plant sources for industrial feedstocks and, thus, increased agricultural diversity, has been widely recommended (11, 13, 17, 18, 22, 26, 29). Underuse of our plant resources may have serious economic consequences for American agriculture if the situation is not swiftly remedied.

The potential benefits to be derived from expanded cropping choices are illustrated by the development of soybean in the USA and rapeseed in Canada (13, 16, 25). Crops diversity has also been proposed to improve pest control, increase soil conservation, and improve the national balance of trade (13, 26).

New crop development, as discussed here, includes the agronomic development and domestication of wild plant species, as well as the adaptation of established crops to new production areas. Recent reviews by Hinman (6) and by Vietmeyer (28) document thousands of plant species that have been identified as potentially important commercial crops awaiting further investigation. Further, tens of thousands of plant species remain unevaluated; the potential for discovering new drug, food, feed, industrial feedstock, fuel, and fiber supplies is vast (1, 18, 31).

The potential of new crops is suggested by the greater than 300% improvement in U.S. corn yields since the beginning of this century (Fig. 1). The development of new crops requires a substantial investment of resources in carefully chosen plants; however, the return in agronomic improvement can be quite high. Evenson et al. (5) estimated the rate of return (over the last 100 years) for public funded agricultural research to be about 85% annually.

This article addresses methods to effectively use our renewable agricultural resources. We explore the challenges facing new crop development through historical and current examples. Finally, we discuss possible directions for new crops in the USA.

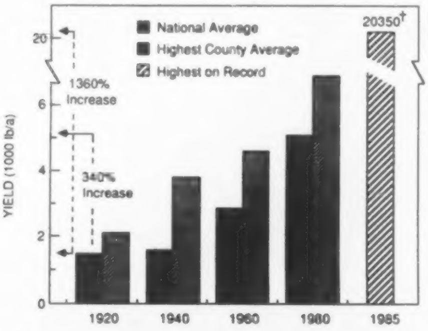

Fig. 1. Corn yields in the United States, 1920–1980, based on national and highest county averages from U.S. Census of Agriculture Summary data, 1921–1981. † The highest on record from a farmer's field was reported by W.L. Nelson and H.F. Reetz Jr. (Herman Warsaw's high corn yields) in the June–July 1986 Crops and Soils magazine. 38(8):5–7.

NEW CROPS FOR U.S. AGRICULTURE

New crops could potentially contribute most to U.S. agriculture through industrial applications, specialty food products, and low-input farming (13, 26). A number of potential new crops for American agriculture are presented in Table 1. Industrial feedstocks could rely on a wide variety of annually renewable farm products (1, 10, 19, 29). For example, jojoba oil could substitute for sperm whale oil as an important industrial lubricant (7, 8); crambe oil could serve as a base for new coatings and plastic treatments (26); and meadowfoam oil has unique properties not yet fully exploited (29). Specialty food items such as cashew nut, tropical fruit, popping bean, and numerous low-fat, low-cholesterol plant products could also expand new crop production (13, 26, 28). Plant-derived biodegradable herbicides, new medicines, reduced urban lead levels (from ethanol-enhanced gasoline with reduced lead content), and soil-conserving cover crops are a few of the society-wide benefits that could be derived from the development of alternate crops and new crop products (13, 15, 18, 26).

To be competitive, U.S. growers are increasingly challenged to use inputs more efficiently and to make marginal cropping environments productive (2, 7). Producing crops under relatively harsh conditions, such as high salinity, low water availability, and low nitrogen regimes present challenges that might be addressed utiliz-

Table 1. Examples of new crop products.

Example products	Crop sources
Lubricating Oils Waxes Cosmetics	Jojoba Meadowfoam Crambe
Herbicides Insecticides	Sunflower Pyrethrum
Rubber Waxes	Guayule
Fiber Pulp	Kenaf Poplar
Soaps Lubricants	Cuphea Guar
Plasticizers	Soybean Crambe Rapeseed
Resins Coatings	Soybean Guayule

ing new crops (28). A new generation of well adapted crop varieties tailored for maximum yields under local conditions can be envisioned.

Specific examples of potential new crops adapted for arid and semiarid regions include: buffalo gourd (2, 6, 8), jojoba (6, 7, 8, 13), and guayule (13, 27). The buffalo gourd is a water-conserving source of starch, biomass, and forage (2). Salinity trials and evaluation of buffalo gourd seeds as a possible source of liquid fuel are in progress (6, 10). Jojoba is a replacement candidate for sperm whale oil to supply liquid wax esters (10). Jojoba meal has also been proposed as a domestic source of tannins (6), an example of a potential new crop which could replace imports with domestic production. Guayule, a bushy plant native to the arid southwest, could potentially supply the strategic rubber needs of the USA (27). Arid land in California, Texas, Arizona, and New Mexico could become a center for rubber production. In the 1940s, guayule rubber yields were on a par with yields from rubber trees (27). Over the last 40 years, agronomic research has dramatically increased rubber tree yields, in contrast to guayule yields. A renewed interest in developing guayule as a domestic supplier of natural rubber has been spurred by an increased awareness of the need for domestic control of strategic defense materials (13, 27).

Kenaf is a promising, annually renewable source of fiber (13). The demand for fiber crops to supply pulp for making paper and paper products is steadily increasing (26). Kenaf can be grown in much of the nation south of Iowa. Yields of over 15 tons of stems per acre could allow this crop to compete with pulpwood and to provide a viable cropping alternative to surplus crops such as cotton (13, 18). Since it is annually renewable, kenaf provides greater flexibility in the use of land, and allows forests to be preserved for multiple recreational uses.

Paddy wild rice is a crop still not completely domesticated; nevertheless, it is in commercial production (13). An expanding market provided by rapidly changing diet preferences of U.S. consumers is insuring continued growth in wild rice production (13).

Plants selected for development into commercial crops deserve careful evaluation. Potential new crops typically have traits that can cause immediate developmental difficulties. Cuphea, for example, is a possible domestic source of lauric acid for production of soaps and related products (24). Cuphea has a number of undesirable agronomic traits, such as shattering seeds and sticky hairs, that complicate harvest (13). A substantial research investment is required to develop an agronomically manageable crop from a wild plant such as cuphea. Crops with seemingly desirable agronomic traits must also be carefully evaluated: they can be the source of unexpected problems upon release. Kudzu is a classic example. Promoted for its soil conservation and forage potential, kudzu has overgrown large areas of the South and become a major weed problem (13). A sustained commitment from the public sector to evaluate and develop new crops would minimize risks of premature introduction of new crops.

The depth and variety of untapped resources for U.S. agriculture have been touched on here. However, public sector investment in new crop development has historically been low and has fluctuated drastically, reflecting shifting research priorities and patterns of research emphasis on the further development of established commodities (G.D. Jolliff, 1986, unpublished data). A strong, sustained voice speaking for new crops has been lacking (17). If benefits from new crop development in the USA are to be realized, changes in national research priorities may be required. With total federal and state funding of agricultural research at its current low level, it is difficult to envision an adequate source of funds for research and development of new crops.

CHALLENGES IN NEW CROP DEVELOPMENT

The complex, all-inclusive nature of new crop development has been a major barrier to development efforts. The failure of just one factor in the equation, such as lack of access to appropriate processing facilities, can spell disaster for the success of a new crop industry (3). The demonstration of profit potential in a new crop may drastically alter its outlook, should entrepreneurial zeal be directed at removing barriers to full production (G.D. Jolliff, 1986, unpublished data). However, to adequately develop a new crop to the point where the potential for profit is demonstrable, a complex matrix of factors must be characterized and challenges overcome.

The commercial success of a new crop demands an orchestration of development for up to 40 different factors, from availability of high quality seed to maximum market penetration (13). A decision matrix of criteria has been developed to assist in the identification of critical factors affecting the development of a new crop (Table 2). A simultaneous assessment of relevant factors, from production to consumption, is useful in contributing to an understanding of possible limiting factors (3). Further, inappropriate new crops for an area can be more easily identified and rejected using a decision matrix approach.

A decision matrix can be designed to categorize the resources in the area under consideration while simultaneously assessing the characteristics of different new crops. As modified from Knox and Theisen, Table 2 presents important steps in production, processing, and marketing of a new crop to be considered. We will discuss some crucial steps in this decision matrix as illustrated by our experience with meadowfoam in the Pacific Northwest. Meadowfoam is being developed to produce an agronomically viable crop from a wild plant species (12). Its seeds are a source of long-chain fatty acids, a new industrial feedstock for which the market has not been fully defined (19, 29).

The situation into which a new crop is to be introduced, or for which it is to be developed, must be considered first. A meticulous cataloging of the land, water, and climate resources is useful in clarifying crop alternatives (Table 2). The physical land and climate must be further characterized as modified by the economic climate (Table 2). Consider, for example, which land resources are cur-

Table 2. Decision-matrix for new crop development (modified from Blase et al., 1981).

Component description	Physical presence	Economic climate
PRODUCTION RESOURCES AVAILABLE		
Land Resources		
Water Availability		
Climate Attributes		
Input Procurement and Availability		
Seed		
Fertilizer		
Farm Labor		
Farm Equipment		
Pest Control		
Production Expertise		
Crop Organizations		
Agricultural Research Programs		
Market Information for Farmers		
PROCESSING AND MARKETING		
Potential for Dependable Supply		
Procurement Resources and Financing		
Government Services and Regulations		
Market Intelligence		
Transport and Storage Facilities		
Processing		
Resources		
Equipment		
Research		
Information Programs		
Commodity Institutions		
Market Penetration		
Market Size		
PLANT CHARACTERISTICS		
Adaptation to Environment		
Production Level		
Expertise Required		
Inputs Required		
Market Development		
Product Versatility		
Competition with Domestic Supply		

rently underutilized. A new crop with a short growing season could potentially expand land use by facilitating doublecropping (6). Introduction and development of a new crop could allow more efficient use of land with limited rainfall, or allow use of high saline irrigation water (13). If land is in high demand for economically viable crops, then development of alternate crops may be less feasible, or necessary, for an area.

Growers in Oregon's Willamette Valley lack cropping options. Production on poorly drained soils has been limited to annual ryegrass seed. Alternatives to annual ryegrass are needed to diversify the economic base and to decrease the incidence of field burning, a process integral to grass seed production, but the focus of public controversy. Meadowfoam, an herbaceous winter annual native to North America, has potential as an oil seed crop to be grown on the targeted soils (13). Wild meadowfoam species grow in wet habitats and are well adapted to production on poorly drained soils in the Willamette Valley (12).

New crop development is affected by the availability of inputs, such as appropriate herbicides, and factors such as the necessity to invest in new equipment (3). The financing environment for investment in production of a new crop, and the farming expertise that could apply to it, both have a strong influence on the potential for successful development. A factor contributing to the strong candidacy of meadowfoam as a new crop for the Willamette Valley was the selection of upright plant growth habit with high seed retention ability. It is harvested with the same equipment already used for grass seed (10).

Processing facilities, transportation, and marketing have been cited as steps in the new crop development process which can act as bottlenecks to the success of a new crop (3, 13). For example, if a new crop requires specialized processing equipment it must be either transported to where this equipment is available, or facilities must be built near the crop production area. Available transportation and processing facilities must be carefully considered in light of the characteristics of the new crops under consideration. Some products are relatively stable, with excellent storage and transportation qualities, which reduces the importance of proximity in processing plants. Routine extracting and processing techniques have been used to produce high quality oil from meadowfoam seed. The oil content and stable qualities of meadowfoam seed have made the location of processing facilities a relatively minor concern in meadowfoam's development. By contrast, this can be a major stumbling block for highly perishable crops such as kenaf, which requires production close to pulp processing plants (23).

The market for a new crop product is a crucial ingredient in successful development efforts (3, 11, 13, 29). An available or readily developed market provides a major incentive for solving problems in production, processing, and transport. However, if there is a well developed market, competition with existing domestically supplied products becomes a factor to consider. An ideal new crop would supply either a product currently imported, or a new item for consumption. Meadowfoam is a source of long-chain fatty acids not yet fully exploited as a unique industrial feed stock (12). This is its greatest challenge. Potential use, rather than well developed current uses, is a stage that can be difficult to overcome.

Once an adequate market is assured, then questions of sufficient and reliable supply arise. Meadowfoam production in the Willamette Valley is assisted by the presence of the Oregon Meadowfoam Growers Association (OMGA), which could facilitate the smooth scale-up of meadowfoam production should market demand improve (29). An exclusive release by the Oregon Agriculture Experiment Station of 'Mermaid', the first commercial meadowfoam cultivar, to the OMGA provided an incentive for undertaking the market and production development work. Protection of the OMGA proprietary position will likely influence meadowfoam development in the future.

There are many steps in the network that support production, processing, and marketing of established crops. Establishing all of these steps in new crop development is an exercise in coordination. A decision-matrix approach

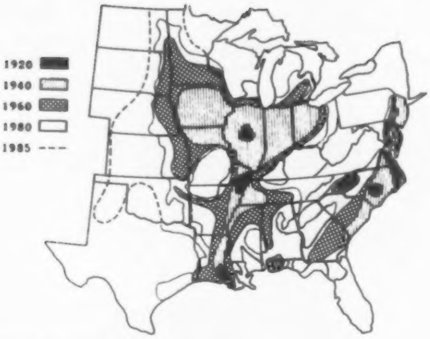

Fig. 2. The expansion of soybean production in the United States during the present century. The acreage for the reported 1985 expansion might be limited in some areas. The map was drawn on the basis of information compiled from the U.S. Bureau of Census and the USDA Statistical Reporting Service.

can help pinpoint factors limiting development at any one point. The challenge then is to identify appropriate new crops for development and to apply a concentrated effort to promote improvement in limiting areas.

SUCCESSFUL NEW CROPS

The development of U.S. soybean production from a minor forage crop to the multi-billion dollar oil crop of today illustrates the challenges and opportunities facing new crop development (Fig. 2). How did the dramatic growth in importance of soybean to the U.S. farmer come about? Acute shortages of vegetable oil during World Wars I and II were accompanied by skyrocketing soybean prices (Fig. 3). Soybean became suddenly profitable, even though the available varieties were low-yielding. This crisis situation was the incentive that pushed soybean over the "entry barrier" faced by new crops and initiated the commercialization process. A few dedicated advocates also played an important role in promoting soybean to its current prominence (13). Considering that soybean was introduced to the USA over 200 years ago (9), the development of its production has not been expeditious. However, the rapid success of the crop once it became a profitable alternative for growers is clear (Fig. 2).

Development of the Canadian rapeseed industry bears striking similarities to soybean development in the USA, but also some insightful differences. The Saskatchewan Wheat Board recognized the need for cropping alternatives for wheat growers (30). Canada committed over 200 Scientist Years (SY, where an average SY is equivalent to approximately $200,000 Canadian) over a 30 year period to rapeseed breeding and genetics (E.J. LeRoux, 1986, personal communication). New varieties were developed for edible oil production. This example demonstrates the potential for a relatively focused investment strategy to overcome the entry barrier to new crop development.

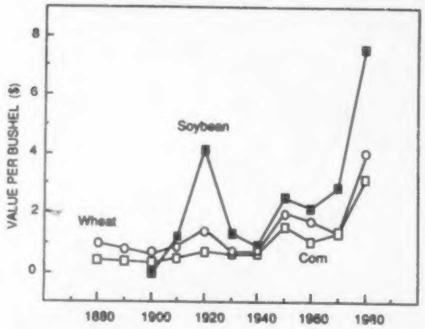

Fig. 3. Commodity value per year for wheat, soybean, and corn. 1880–1980, according to the U.S. Census of Agriculture Summary data, 1880–1981.

Either a scarcity situation such as described for U.S. soybean development, or a planned, sustained research-investment approach such as exemplified by Canadian rapeseed development can boost a new crop over the entry barrier. Once a new crop can be grown profitably, challenges such as unique processing requirements or marketing problems will be addressed by both the private and public sectors. By contrast, public support of research is required for initial development of a new crop (G.D. Jolliff, 1986, unpublished data; 12). At the point where adequate rates of return on investment can be projected within a short time, the development risk becomes quantifiable and the private sector can be expected to address further development needs (Fig. 4).

The enormity of the entry barrier facing new crops must be recognized. It is easy to develop unrealistic expectations of new crops. Development of a crop to the profitable stage requires an intensive, sustained effort (G.D. Jolliff, 1986, unpublished data). The slow commercialization of U.S. soybean production (Fig. 2) illustrates the long-term view that is needed to set realistic expectations for new crop development. However the potential exists, with available technology, to achieve rapid progress in such development. The successful commercialization of rapeseed in Canada demonstrates the effectiveness of a concentrated research effort (16, 25, 30). A relatively modest investment in 1952 of about 1.4 SY (in rapeseed genetics and plant breeding) per million dollar rapeseed value initiated the development of Canadian rapeseed at an unprecedented rate (Table 3). In contrast, compare the .01 SY per million dollar soybean value invested by the U.S. public sector in soybean breeding and genetics research for the same year (Table 3).

What are the overall societal benefits incurred from a successful new crop development program? The Canadian rapeseed venture is a dynamic example of sustained support by established commodity producers for the development of new cropping options. A recent assess-

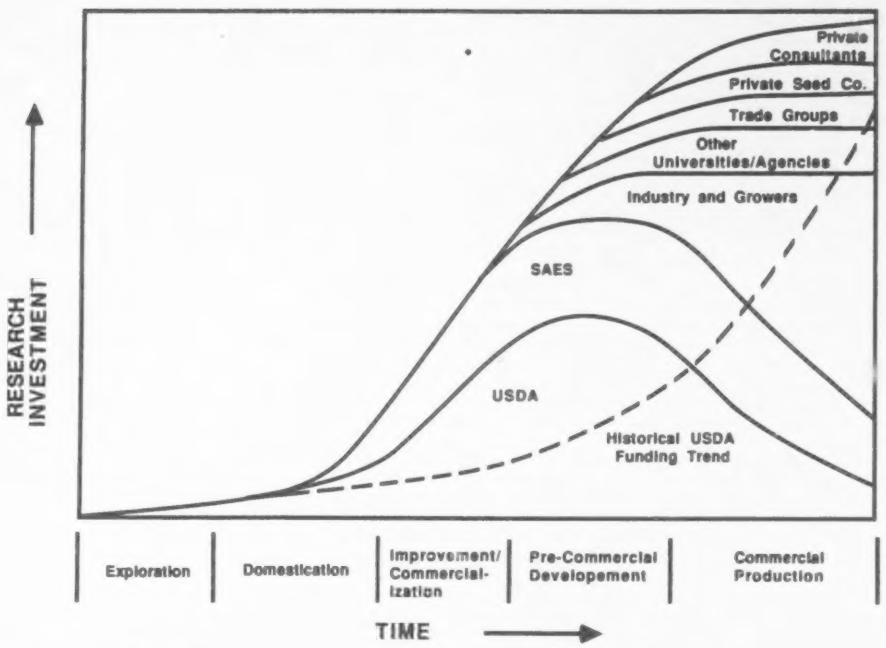

Fig. 4. Model of research investment strategies to support commercial development of new crops.

ment estimated the annual internal rate of return on investment in rapeseed at 101% (16). Consumers and society-at-large benefited equally from increased rural prosperity, from a positive balance of trade, and from greater availability of locally produced edible oil (16). Canadian development of rapeseed as an alternate crop significantly stabilized grower income.

THE FUTURE OF AGRICULTURE: NEW CROPS' ROLE

A future U.S. agricultural scenario, involving full use of our nation's capacity to produce an excess of annually renewable farm products, can be envisioned. For example, farmers in the Southwest might grow a variety of water-conserving, low input plants such as buffalo gourd for starch and jojoba for industrial oils (2, 6, 27). Wetter areas in the South might produce tallow from the Chinese tallow tree and pulp from fiber crops such as kenaf (13, 23, 29). Fields of cuphea for soap manufacture, and super-sorghum as a feed-base for industry and fuel, can be envisioned in the Southeast (4, 24). Midwestern fields of corn might be intercropped with a nitrogen-fixing, weed-suppressing, and soil-conserving legume. A short-season crop such as crambe might be doublecropped with wheat in the North Central states (29). On the West Coast, locally adapted cultivars of small grains and turf grasses (for seed) might be grown in rotation with industrial feedstock crops such as meadowfoam and pyrethrum (15, 19).

American agriculture, safeguarded by the expansion of cropping options, would utilize soil and water resources more efficiently. Further, strategic industrial feed-stocks would be produced under U.S. control, con-

Table 3. Comparison of USA and Canada public sector investment in soybean and rapeseed development, respectively (25; R.W. Judd, 1986, personal communication).

	Crop value (million $)		Public geneticist/breeders			
			Scientist Years (SY) (no.)		Ratio (SY/million $)	
Year	U.S. soybean	Canada rapeseed	U.S. soybean	Canada rapeseed	U.S. soybean	Canada rapeseed
	U.S. currency	Canadian currency				
1952	750	0.21	7.3	0.3	0.010	1.428
1962	1 544	20	13.0	1.5	0.008	0.075
1972	3 560	168	26.0	8.5	0.007	0.051
1982	12 000	514	32.0	15.8	0.003	0.031

tributing positively to the balance of trade. Improved productivity and increased stabilization of farm income and farm soil might be expected from the widespread availability of profitable, locally adapted cultivars. Underutilized harsh environments could be made competitively productive.

Methods of accelerating development of profitable new crops for U.S. agriculture need to be explored. Biotechnology could play an important role in developing cropping alternatives (14). Documenting existing genetic variation would also expand the range of new farm and forest products (28, 31). However, tools such as biotechnology and evaluation of existing genetic diversity may not necessarily be used effectively. It has been argued that institutional reform can be a reliable means of bringing about needed change (20). The establishment of a dynamic, multidisciplinary, entrepreneurial foundation focused on new farm and forest products has been proposed recently by a national task force (17). Members of industry, government, academia, and production agriculture, working together in a collaborative, multidisciplinary approach have an opportunity to foster accelerated new crop development (13, 17).

The benefits for consumers and producers alike from the improvement of cropping alternatives cannot be ignored. Our renewable agricultural resources are only beginning to be tapped. Useful first steps would include a realization of the complexity involved in new crop development—such as identified in the decision-matrix approach, and implementation of a unified, can-do attitude throughout agriculture. Hopefully, substantial and responsible research in new crop development is forthcoming.

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Meadowfoam (*Limnanthes alba*):

Its Research and Development as a Potential New Oilseed Crop for the Willamette Valley of Oregon

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COVER PHOTO: A field of meadowfoam in full bloom in the Willamette Valley.

Preface

Few new crops have been discovered, domesticated, and developed by modern society. The recent farm scale production of meadowfoam in western Oregon is an interesting exception. Research experimentation plus farm-scale production of meadowfoam have shown this crop is well adapted to western Oregon. This report summarizes the technical information related to the agronomic development of meadowfoam during the last 20 years.

The topics of economics, processing, and marketing are not addressed in this bulletin, but will be reported later as data become available. In the meantime, meadowfoam should be considered as a new crop with as many uncertainties about its potential uses and profitability as was the case for crops such as the soybean and sunflower in the 1920s. However, research to date indicates meadowfoam could be a potentially valuable new crop for western Oregon.

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Meadowfoam *(Limnanthes alba)*:

Its Research and Development as a Potential New Oilseed Crop for the Willamette Valley of Oregon

Gary D. Jolliff, Ian J. Tinsley, Wheeler Calhoun, and Jimmie M. Crane

INTRODUCTION

There are many reasons for interest in new crops. An early objective of the U.S. Department of Agriculture was to "procure, propagate, and distribute among the people new and valuable seeds and plants" (USDA, 1862). The meaning of "valuable seeds and plants" has changed throughout history. Production of food, feed, and fiber for domestic consumption in the 1800s by America as a developing nation was very important. During the last quarter century, agricultural export commodities have become increasingly important. The energy situation is now causing a change in perspective as "valuable seeds and plants" are viewed as sources of renewable industrial raw materials and energy.

Meadowfoam Identified as a Potential New Crop

The analysis of meadowfoam *(Limnanthes douglasii* R.Br.) seed oil was first reported by USDA research scientists at the Northern Regional Research Laboratory, Peoria, Illinois, working on an extensive program to search for new industrial raw materials from plants (Earle et al., 1959). A prime reason for seeking new crops at that time was to help alleviate troublesome surpluses of several major crops (White and Wolff, 1968). That research effort resulted in the chemical screening of 6,500 species of wild plants (Princen, 1979). A significant number of plant species were identified as excellent candidates for the production of desirable products. Substantial interest in meadowfoam as a source of industrial oil was aroused when the oil was used to derive liquid wax esters which had properties very similar to those of jojoba *(Simmondsia chinensis* [Link] Schneider) (Miwa and Wolff, 1962).

In 1971, meadowfoam was named as the most promising substitute for sperm whale oil which had been banned as a U.S. import by the Endangered Species Conservation Act of 1969. However, budgetary limitations kept research projects on meadowfoam very small (Cook, 1971).

New Crop Screening in Oregon

Between 1963 and 1979, the new crops project at the Oregon State Agricultural Experiment Station tested several hundred plant introductions (including 532 accessions, 122 species, and 57 genera). Several of the plants which had shown some promise in the USDA investigations grew satisfactorily at the Oregon State University Hyslop Crop Science Field Laboratory near Corvallis, Oregon.

Meadowfoam was the only plant found to be well adapted to poorly drained "white land" in the mid- to southern Willamette Valley. This agricultural area was recently described by Tsutsui (1979).

Oregon Interest in Meadowfoam

Meadowfoam is of special interest to producers who farm the approximately 80,000 hectares (200,000 acres) of this land on which annual ryegrass *(Lolium multiflorum* Lam.) seed production is the only adapted cash crop. Annual ryegrass seed production frequently exceeds demand, resulting in depressed prices. Therefore, it can be economically advantageous to the region to reduce the annual ryegrass acreage. In addition, there is no crop residue problem after meadowfoam harvest. Since the plant is not fibrous, threshing pulverizes the dry vegetation, leaving only a trace of fine particles. Thus, the acreage diverted from ryegrass would not require sanitation by open field burning.

Meadowfoam may also fill a need for the first crop in a double-cropping system involving the late plantings of bush beans or other irrigated cannery crops (sweet corn, table beets, carrots, etc.) in the Willamette Valley. Bean growers have expressed a need for an annual winter cover crop that does not promote continued growth of bean pathogens.

Having a choice of crops to grow in a farming operation also aids in spreading the producers' risks and workload. The economy of Oregon could benefit from additional income if meadowfoam is produced as a source of industrial raw materials.

Unanswered Questions

Higher costs for petroleum have caused the U.S. chemical industry to consider the potential of agricultural crops to supply basic chemical feed stocks (Grounds, 1980).

Questions about meadowfoam prices, markets, processing, and uses are logical to ask, but are difficult to answer. Even though meadowfoam was produced on a farm scale (35 acres) in 1980, commercial development of this new crop will require years of effort. Private industry generally is not willing to invest in developing new crops until a significant financial incentive is visible (Rothfus, 1980). Soybeans, for example, required more than a century for full development of production and marketing in the United States, even though the soybean plant had been domesticated several thousand years earlier. By contrast, meadowfoam was domesticated less than 30 years ago. Similarly, major new uses of corn syrup have been developed just recently, even though this crop has led the nation for decades in total value of production. While USDA chemists worked on some of these new uses for corn products, and predicted the potential for their use, the appropriate economic and political environment in industry was essential for the actual commercialization to take place.

Establishing a price for meadowfoam is difficult because markets change. For example, meadowfoam oil might be valued comparably to rapeseed oil in an active market channel. But it might be worth two or three times as much as rapeseed oil if ways are found to capitalize on its unique composition. This would give the developing industry a competitive advantage.

Continued efforts from public and private sectors in Oregon and the U.S. Department of Agriculture will be needed to make progress in meadowfoam development until the profit potential becomes sufficiently visible so private industry will assume leadership in utilization research and market development.

MEADOWFOAM SEED OIL— A CHEMICAL PERSPECTIVE

Meadowfoam is valuable as a potential new crop because its seed oil is a source of long chain (C_{20} and C_{22}) fatty acids. Some perspective on the potential utility of this oil can be deduced by considering its chemical composition with reference to other oils in commercial use. Such an analysis should provide an indication of how this oil could provide unique advantages on the one hand or where, on the other hand, it might serve as a simple replacement for oils presently in use.

Fatty Acid Composition

The fatty acid composition of meadowfoam seed oil is summarized in Table 1, along with that of other oils that might be considered its closest "relatives," chemically speaking.

Table 1.
Fatty acid composition of meadowfoam and related oils.

Fatty Acid	High Erucic Rapeseed (Canadian)	Crambe	Meadowfoam
		%	
14:0[1]	...	0.1	Tr
16:0	2.5	1.7	0.2
16:1	0.2	0.3	0.2
18:0	2.6	...	Tr
18:1	16.3	16.7	2.0
18:2	15.3	7.8	0.2
18:3	8.9	6.9	...
20:0	0.8	1.3	2.0
20:1	11.6[2]	2.9	65.0[3]
20:2	...	Tr	0.4
22:0	1.4	2.7	...
22:1	40.0	55.7	20.0[4]
22:2	0.6	...	10.0[5]

[1] This abbreviation designates the number of carbons in the fatty acid chain (14) and the number of double bonds (0).

[2] Δ11

[3] Δ5

[4] 33% Δ5, 67% Δ13

[5] Δ5, 13

Note that the oil contains two forms of 22:1, erucic acid (Δ13) and an isomer (Δ5) which corresponds in the double bond location to the major fatty acid, 20:1. The Δ13 isomer constitutes approximately two-thirds of the total 22:1 (Smith et al., 1960). There is essentially only one report of the fatty acid composition of this oil (Miwa and Wolff, 1962) along with a survey of other species of the genus *Limnanthes* (Miller et al., 1964).

Unique Aspects of Meadowfoam Seed Oil

1. Source of Eicosenoic Acid. The amount of 20:1 in this oil is the highest of any known oil. Considering its relatively simple fatty acid distribution, meadowfoam provides a unique source of this fatty acid.

2. Source of C_{20} and C_{22} Fatty Acids. No other seed oil has such a high percentage of fatty acids of this chain length. Fish oils are used as a source of these fatty acids but the best source, herring oil, contains only 40 percent of C_{20} and C_{22} fatty acids (Stansby, 1979) compared to >90 percent for the meadowfoam oil. If saturated acids were to be

produced by hydrogenation, the meadowfoam oil would be superior with the C_{20} and C_{22} acids containing only 1-2 double bonds/molecule; the marine oil's fatty acids of this chain length contain 4-6 double bonds/molecule. Assuming any geographical variables are minimized, one would expect the composition of a meadowfoam oil to be significantly more uniform than a marine oil. Crambe and high erucic acid rapeseed also have substantially lower levels of the C_{20} and C_{22} fatty acids.

Oxidative Products

Unsaturated fatty acids may be cleaved by oxidative processes yielding shorter chain monobasic and dibasic acids, some commercially significant. The nature of the acids formed depends on chain length and location of the double bonds. Theoretical yields of the different acids produced from 100 g of meadowfoam fatty acids are summarized in Table 2.

Table 2. Short chain acids derived from oxidation of major fatty acids of 100 g of meadowfoam oil fatty acids.

Parent Fatty Acids			Derivative Acids			
			Monobasic		Dibasic	
Δ5	20:1	65.0 g	C_{15}	50.7 g	C_5	27.7 g
Δ5	22:1	6.6	C_{17}	5.3	C_5	2.6
Δ13	22:1	13.4	C_9	6.3	C_{13}	9.7
Δ5, 13	22:2	10.9	C_9	4.7	C_5 3.9	C_8 5.3
Overall theoretical yields						
			C_9	11.0 g	C_5	34.2 g
			C_{15}	50.7	C_8	5.3
			C_{17}	5.3	C_{13}	9.7

The two major products are a C_{15} monobasic acid and a C_5 dibasic acid, glutaric acid. Whether these two acids would provide an advantage for meadowfoam oil is not known. The C_{15} acid is unique but would be expected to compare with myristic acid (C_{14}) or palmitic acid (C_{16}) which are available by direct hydrolysis of other oils.

The C_9 monobasic acid and C_{13} dibasic acids find commercial use but can be produced in higher yields from the oxidation of oils containing high levels of oleic or erucic acid.

Waxes

By reducing the meadowfoam acids to alcohols and then forming esters with those acids, C_{40}-C_{44} waxes similar to those of jojoba oils may be produced. Unless there was some unusual price differential between the two oils, there would not appear to be any particular advantage in producing the waxes from meadowfoam oil.

General Derivatives

Excluding food use, defined end uses for fatty acids have been identified for seven main classes of derivatives (Kern, 1979). The latter would include various nitrogen derivatives, alcohols, sulfates, sulfonates, etc. These derivatives may find uses as surfactants, plasticizers, or lubricants. Such derivatives could be produced from the fatty acids of meadowfoam oil. Their commercial use would depend on their actual physical properties in competition with other sources. There are some indications that longer chain derivatives, in some cases, may improve product performance (Weiss et al., 1979).

Replacement of Oils

Of the oils in commercial use, a high erucic acid rapeseed oil would have a fatty acid composition most similar to meadowfoam oil. Rapeseed oil would be slightly more saturated, primarily because of the linolenic (18:3) content. It also would contain a lower proportion of the C_{20}-C_{22} fatty acids.

The principal industrial use of the high-erucic rapeseed in the United States is as the sulfur polymer, "factice," in the rubber industry. There is some indication that the sulfur-treated meadowfoam oil could provide a suitable product substitute. Other uses listed for rapeseed oil by Ohlson (1972) are not so critically related to fatty acid composition. Meadowfoam oil might not be a reasonable consideration for a replacement then. Such uses would include various lubricant preparations, detergent additives such as the sulfate derivatives, and plasticizers as epoxide derivatives. But, because of the location of the double bonds, its oxidative products are quite different from rapeseed oil.

The literature on the chemistry of meadowfoam oil was recently summarized (Jolliff, 1981).

THE MEADOWFOAM PLANT

The genus *Limnanthes* (family Limnanthaceae), described in 1833 by Robert Brown, is native to northern California, southern Oregon, and Vancouver Island, British Columbia (Mason, 1952). It is a low-growing (Photo 1) herbaceous winter annual that is well adapted to the Mediterranean climate of the Pacific Coast. The common name "meadowfoam" was given because of the appearance of the nearly solid canopy of light-colored flowers at full bloom (Photo 2). Several taxonomic studies of *Limnanthes* have been

Limnanthes alba plant in rosette in February in the Willamette Valley.

published (Mason, 1952; Ornduff and Crovello, 1968; Ornduff, 1971, and Arroyo, 1973a).

Habitat Survey

Gentry and Miller (1965) explored the feasibility of developing *Limnanthes* as a crop plant. Their initial assessment of *Limnanthes* in its natural habitat revealed nothing to discourage economic interest in the plants. They observed that it has a growing season and harvest period similar to winter grains and has shown adaptability to cultivation in a wide range of soils and climates. The short life cycle and genetic flexibility suggested possibilities of rapid progress in crop improvement. The plants appeared to be efficient in synthesis of dry matter and produced a high ratio of seed to vegetative dry matter. High seed retention, low water use requirement, and slightly higher oil content was found in members of the Inflexae (petals fold inward after pollination and during maturation of the fruit) group of species. *Limnanthes alba* var. alba was suggested as having the most adaptive potential for good perfor-

A field of meadowfoam in full bloom in May in the Willamette Valley.

L. alba anthers shed pollen before the stigma is receptive and therefore insect pollination is important for seed set.

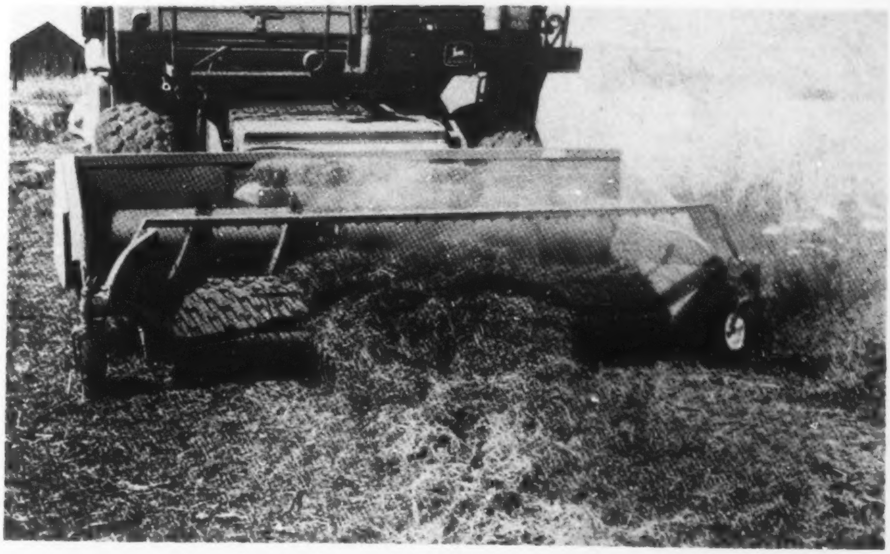
L. alba seeds (nutlets) contain 20-30 percent oil.

Each flower can produce as many as five seeds.

mance under cultivation. This variety evolved in central and northern California during the last century on the cultivated sandy and silty loam soils used to grow winter grains. It is a relatively xerophytic species and can set seed on the last of the seasonal soil and stem moisture (Gentry and Miller, 1965).

Introduction and Initial Plantings

The first reported field trials involved *L. douglasii* seed from Europe, which was planted as a winter annual at Glenn Dale, Maryland, in 1961 (Higgins et al., 1971). Seed germination sensitivity to high soil temperature was observed. Optimum temperatures for seed germination of 10 species of *Limnanthes* ranged from ca. 5°-15°C (Toy and Willingham, 1966). The seeds of some species were induced into secondary dormancy when imbibed at 27°C (Toy and Willingham, 1967). The seed dormancy problem was encountered with some *L. alba* plant introduction materials at Corvallis but the dormancy characteristic was reduced to less than 10 percent during the mass selection phase of the development of the cultivar, Foamore (Calhoun, unpublished data).



Timely cutting, and proper combine adjustment are critical for a successful harvest.

Germplasm Collection and Distribution

In 1962, Gentry collected 28 *Limnanthes* accessions from California and Oregon to provide germplasm for new crop research programs. They were planted in the fall at Chico, California, and Glenn Dale, Maryland. Again, *L. alba* showed the most potential as a crop because of superior seed retention and erect growth habit. Further evaluation of *L. alba* var. alba accessions 283702 and 283703 was suggested. *Limnanthes* had promise as a new oilseed crop because experimental yields of 1700 kg/ha or more appeared attainable on a commercial basis through plant improvement and the use of sound cultural practices. *L. douglasii* was planted as a spring annual in 1963 at Palmer, Alaska. It had indeterminate growth and an estimated yield of 2,500 kg/ha; the maximum yield at this site in 1967 was 820 kg/ha. Seven *Limnanthes* accessions were first grown in the Willamette Valley in 1966 at Corvallis to evaluate fall versus spring planting. Only the fall planting was suited to the environmental conditions at Corvallis. *L. alba* var. alba yielded the highest at 1,350 kg/ha.

Limnanthes was grown and hand-harvested at all four of the above locations. The Palmer, Alaska, site required planting as a spring annual. The plants continued to grow all summer and thus presented some problem of plant maturation and seed ripening for harvest. There was significant loss of stand at the Glenn Dale, Maryland, site because of winter heaving. The onset of early, warm conditions at Davis, California, in the spring caused termination of vegetative growth and generally low yields. The climate of the Willamette Valley of Oregon seemed to be well suited for the production of this crop (Higgins et al., 1971).

Variety Development

The major agronomic problems associated with the initial use of wild meadowfoam populations were poor seed retention, low yield, and prostrate growth (Kanuika, 1969).

In 1971, Calhoun and Crane found that seed losses from shattering ranged from an average of 16 to 54 percent for two *L. alba* accessions under two harvest dates while three *L. douglasii* accessions had seed losses ranging from 71 to 93 percent. The *L. douglasii* had a total yield of 1980 kg/ha and the *L. alba* averaged less than 660 kg/ha. Notation was made of the desirability of combining the yield qualities of *L. douglasii* with the seed retention characteristics of *L. alba*. However, Mason (1952) had not been able to obtain seed from attempted cross pollination of *L. alba* x *L. douglasii*. Therefore, Calhoun and Crane directed attention to the improvement of *L. alba* since the reflexed flower characteristics of *L. douglasii* gave no encouragement for the possibility of reducing seed shatter to an acceptable level.

"Foamore," the first cultivated meadowfoam variety, was released by the Oregon Agricultural Experiment Station in 1975. Its superior characteristics include: greater plant height (25 to 30 cm), upright growth habit, fair seed retention (50 to 85 percent), and good seed yield (1,000 to 1,500 kg/ha). At Corvallis, it flowers about May 20 and is ripe for harvest in early July.

It originated as a single plant selection made in 1970 from plant introduction accession PI 283704 of *Limnanthes alba* var. alba. The single plant was self-pollinated for seed increase. Mass selections were made in 1971 from progeny of the selfed plant. Mass selections from open-pollinated spaced plants, for upright growth and improved seed retention, were continued in 1972, 1973, and 1974.

An improved experimental line, selection 703-A, yields as well as the Foamore variety (Table 3), and is superior to Foamore in seed retention (Table 4). This selection is being considered for release by the Oregon Agricultural Experiment Station as the variety, Mermaid.

Table 3. Mean total[1] seed yields in seven years for two *Limnanthes alba* cultivars grown at Corvallis, Oregon.

Cultivar	Year 1973	1975	1976	1977	1978	1979	1980	Mean
	kg/ha							
703-A	1956	1296	1688	866	963	1123	981	1239
Foamore	1844	1207	1642	825	902	1013	946	1197

[1] Includes the seed harvested by the plot combine plus the seed recovered by vacuum sweeping the seed remaining on soil in the plot.

Table 4.
Mean percent seed loss in five years for two *Limnanthes alba* cultivars grown at Corvallis, Oregon.

Cultivar	Percent seed remaining on ground after harvest[1] Year 1976	1977	1978	1979	1980	Mean
	Percent					
703-A	8.4	11.3	13.1	3.9	5.4	8.4
Foamore	55.1	12.8	17.5	11.1	14.0	22.1

[1] Data for 1976-1978 include amount of seed on ground which passed through the plot combine harvester. Data for 1979 and 1980 were corrected (reduced) by the amount of seed which passed through the harvester and back to the plot.

Producers have expressed a willingness to grow meadowfoam as soon as a profitable market is developed. It was grown and harvested successfully on an experimental farm-scale operation on 35 acres in Linn County, Oregon, in 1980. That occasion marked significant progress where the wild meadowfoam plant had been modified to fit mechanized production. However, much additional research is needed to improve seed yields. It is important to maintain a balance in the progress made in agronomic development of the plant, and oil utilization research. The latter topic is not addressed in this publication, but development in that area will influence agronomic research planning.

Two research areas of special importance in the development of higher yielding meadowfoam varieties are: (1) the development of a self-pollinating variety of the *Limnanthes alba* plant type, and (2) delineation of the physiologicl factors related to seed fill which cause variability in seed yields between years.

The flowers of *L. alba* are protandrous (Mason, 1952), with anthesis occurring one to four days before the stigma matures. Viable pollen is too heavy to be carried by the wind, so insects are required for pollination. The honeybee *(Apis mellifera)* was found to be the primary pollinator in Corvallis, Oregon, with some flower visitation by syrphid flies (Burgett, 1978). Meadowfoam blooms in May in the Willamette Valley when the temperature, precipitation, sunlight, and wind speed commonly are unfavorable for honeybee foraging. In seasons when these adverse weather conditions occur, seed production is below the potential because of lack of pollination.

The requirement for insect pollination causes additional problems in conducting agronomic research. Experimental field plot treatments often influence the time of flowering. For example, nitrogen fertilizer application in experimental yield trials generally delays flowering. This results in different weather conditions for pollination of the plots treated with nitrogen than for the check plots.

The confounded data from such experiments are difficult to interpret. Thus, a self-pollinating (non-protandrous) *L. alba* variety would produce seed with less vulnerability to weather (via lack of pollination), and would be useful for conducting agronomic development research free of the confounding effects of incontrollable insect pollinator variables.

Initial efforts to develop a self-pollinating meadowfoam cultivar at the Corvallis station involved the application of selection pressure on populations of breeding materials which theoretically had potential autogamy. Individually spaced plants of *L. alba* var. alba and *L. alba* var. *versicolor* were caged in 1975 through 1980 to exclude insect pollinators. Very limited progress was made toward a self-pollinating variety.

Limnanthes floccosa Howell is believed to have originated from *L. alba* (Arroyo, 1973b), which suggests the possibility of successful hybridization of the two species. In 1977, *Limnanthes floccosa* ssp. *pumila* (Howell) Arroyo (PI 283721) and *Limnanthes floccosa* spp. *grandiflora* Arroyo, (Arroyo, 1973a) were crossed with five selections of *L. alba* (Table 5) with the goal of incorporating the self-pollinating characteristics of *L. floccosa* into *L. alba*. *Limanthes floccosa* blooms a month earlier than *L. alba*, making it impossible to cross the two species under field conditions. Daylength and temperature were controlled for each species so flowering was synchronized in a greenhouse. Sixty-four seeds were harvested from the crosses but only three seeds germinated.

Table 5.
Crosses made between *Limnanthes alba* and *Limanthes floccosa*, 1977.

L. floccosa parent	*L. alba* parent	No. crosses	No. seed produced	No. seed that germinated
PI 283 721*	Foamore	2	5	0
PI 283 721*	ORL 75-60	1	2	0
PI 283 721*	ORL 75-64	2	3	0
PI 283 721*	ORL 75-66	4	12	0
PI 283 721*	A73-367900-3	1	3	0
ORL 75-57**	Foamore	3	8	0
ORL 75-57**	ORL 75-60	3	7	1
ORL 75-57**	ORL 75-64	2	6	1
ORL 75-57**	ORL 75-66	6	12	1
ORL 75-57**	A73-367900-3	2	6	0

* ssp. *pumila*
** ssp. *grandiflora*

Using the same technique in 1978, three subspecies of *L. floccosa [pumila, bellingeriana* (M. E. Peck) Arroyo, and *grandiflora]* were crossed reciprocally with seven *L. alba* cultivars and selections. Seed was not produced from any of the crosses in which the male parent was *L. floccosa*. All crosses using *L. alba* as the male parent and *L. floccosa* as the female parent produced some seed.

Seed from crosses made between *L. floccosa* spp. *grandiflora* and *L. alba* germinated and those seedlings were transplanted into the field in November, 1978, for evaluation as F_1 progeny during the spring of 1979. Seed from all crosses of *L. floccosa* ssp. *pumila* and *L. alba* did not germinate; likewise, there was no germination of seed from crosses made between *L. floccosa* ssp. *bellingeriana* and *L. alba*.

Limnanthes alba flowers have petals that conspicuously exceed the sepals in length at anthesis. *L. floccosa*, on the other hand, has petals which are equal in length to the sepals at anthesis. F_1 plants from a cross between these two species should have intermediate petal length. All 27 individul plants from the *L. floccosa* ssp. *grandiflora* x *L. alba* crosses showed this intermediate petal length (Tables 6 and 7), indicating they were true F_1 hybrids.

Table 6.
Flower characteristics and seed yields of individual F_1 meadowfoam plants from OLC-2 (*L. floccosa*) x 703A (*L. alba*) cross, 1978.

Plant	Petal length	Sepal length	Seed yield/plant
	(mm)	(mm)	(gm)
1	12	10	3.91
2	12	10	10.58
3	12	10	6.29
4	12	11	4.62
5	13	12	9.98
6	11	9	7.17
7	12	10	1.70
8	12	10	10.68
9	11	9	2.87
10	12	10	6.45
11	12	10	3.23
12	12	11	3.82
13	13	11	8.73
14	12	10	5.29
Average	12.0	10.2	
OLC-2	9	9	2.48
703-A	19	12	

Table 7.
Flower characteristics and seed yields of individual meadowfoam plants from OLC-2 (*L. floccosa*) x 77-84 (*L. alba*) cross, 1978.

Plant	Petal length	Sepal length	Seed yield/plant
	(mm)	(mm)	(gm)
1	12	11	4.40
2	14	12	22.49
3	13	11	2.40
4	12	10	3.56
5	12	10	11.10
6	12	10	10.30
7	13	11	7.93
8	13	11	4.62
9	13	12	8.20
10	12	11	6.50
11	12	11	7.24
12	13	12	5.40
13	12	10	8.23
Average	12.5	10.9	
OLC-2	9	9	2.48
ORL 77-84	15	10	5.25

A portion of the seeds from each of the above 27 F_1 plants were germinated in late summer of 1979. Fifty individual plants (grown in peat pellets) from each of the 27 F_1 parents were transplanted into a space-planted field nursery for evaluation as F_2 segregates during the spring of 1980. Fifteen plants (3 groups of 5 each) from each of the 27 F_1 parents were placed in the greenhouse for evaluation during the winter of 1979-80. Flowers on each plant were evaluated for the degree of protandry by recording dates of anthesis and stigma maturation. Non-protandrous F_2 segregates in the greenhouse were backcrossed to *L. alba* to recover the desirable agronomic characteristics in a self-pollinating plant. Data from the segregating F_2 populations in the greenhouse were used to focus attention on the most promising segregates in the 1,350 individual plants in the field which were evaluated for flower morphology, plant size and structure, and seed yield. Some of the plants were open-pollinated and some were self-pollinated by excluding insects with cages.

Some F_2 segregates in the greenhouse in 1979-80 set seed without insect pollination. Therefore, F_1 plants, from crosses made in the winter of 1979, also were backcrossed to *L. alba* in the greenhouse during the winter of 1980.

The size and scope of the future meadowfoam breeding program at Oregon State University will be determined by availability of funding and by the relative rate of progress made in meadowfoam oil utilization research. Increasing seed yields result in greater economic returns for the producer and/or more competitive prices for the crop. In either case, higher yielding varieties will enhance the development of meadowfoam. However, concurrent research on meadowfoam oil utilization with the goal of market development is needed to justify an intensive meadowfoam breeding and improvement program.

Other meadowfoam breeding work has been included in research initiated at Davis, California, in 1972. The purpose of that research was to "evaluate the Oregon selections for productivity in California; broaden the genetic resources by larger collections through wild and agronomic surveys, and, develop new materials through hybridization, selection, and genetic analysis of variation." The primary objectives were to select for taller, more competitive plants with higher seed yield, higher oil content, and a better branching pattern; and breed for flower seed development in synchrony, and better seed retention (Jain et al., 1977).

Brown et al. (1979) have described the variability in 16 populations of *L. alba* found in nature in northern California. They noted that variation in traits such as levels of self-pollination, growth habit, seed retention, percent oil in the seed, and fatty acid composition of the seed oil, suggested the potential use of hybridization between species and within species to broaden the genetic base early in the domestication and improvement of meadowfoam.

Brown et al. (1979) reported the initiation of inbreeding and selection experiments to develop inbred lines for hybridization and selection experiments to recombine desirable traits. Hybridization work at Oregon State University has been limited to controlled interspecific crosses for the development of self-pollinating varieties, and semi-controlled cross pollination among superior *L. alba* selections in isolated space-planted nurseries. Planned hybridization from specific superior parents should be initiated for characteristics such as fatty acid composition of seed oil when results from oil utilization research indicate the preferable composition for use in specifically viable markets.

Agronomic Characteristics

Wild meadowfoam plants generally are unsuited for field production because:

1. Plants are too short or grow too close to the ground for mechanical swathing or combine harvesting.
2. Flowers of the alba species require insect pollination to set seed; consequently, seed set may vary substantially because of adverse effects of weather on insect pollinator activity.
3. Excessive seed shatter may occur before the crop is mature enough for mechanical harvest.
4. Seeds have a secondary dormancy mechanism which is induced when planting and water imbibition take place at temperatures above 16°C (69°F), resulting in low germination and poor stand establishment.

The wild populations of meadowfoam are quite variable in plant characteristics (Brown et al., 1979; Brown and Jain, 1979). This variation has provided a basis for progress in selecting for characteristics favorable for field production, resulting in the release of improved varieties. In 1967, Calhoun began crop improvement and production research in Corvallis, Oregon, on the above problems to increase yield.

Adaptation of Meadowfoam to the Willamette Valley

The growth requirements of meadowfoam are well matched to conditions in the Willamette Valley. The soil temperature and moisture at the start of the rainy season in mid-October to mid-November are ideal for the germination and establishment of meadowfoam. The mild winter temperatures stimulate continuous vegetative growth in the rosette stage. Periods with average daily temperatures below 4°C (40°F) commonly occur each winter and temporarily limit plant growth. Plant mortality from heaving of plants from soil during freezing and thawing has been observed only occasionally. The higher temperatures and longer daylength of late February stimulate additional leaf development and upright growth. The 12-hour daylength in March is long enough to initiate reproductive growth. During April, the leaf area becomes fully developed and flower buds are formed. Bloom occurs in May and seeds develop during June. The crop ripens in early July as the seasonal precipitation subsides.

Adaptation to Research

Mason (1952) described meadowfoam as one of the easiest plants to handle in a laboratory because it is readily transplanted at any stage of development and will grow in a wide variety of soil types. Some parts of the plant will develop to maturity even after the roots have been removed. By controlling temperature and daylength, three generations of meadowfoam can be grown in one year. This convenience is offset partly by the difficulty of dealing with insect pollination variables on *L. alba*.

PRODUCTION

Adaptation of Meadowfoam to Farming Systems

The practicality of growing meadowfoam instead of annual ryegrass depends largely upon seed price but also upon the timing of agronomic production practices (Jolliff *et al.*, 1981). The seedbed for meadowfoam can be prepared with the same equipment used for wheat and grass seed fields. Timing of the seedbed preparation is not critical for meadowfoam seeding, but must be done early enough to precede the fall rains so equipment can be used on fine-textured soils. Meadowfoam can be seeded, fertilized, sprayed, swathed, combined, cleaned, and processed with the same equipment used for ryegrass seed.

Planting

A primary goal of the Oregon research on planting was to develop procedures which would result in a uniform stand of vigorous plants that give complete ground cover by late December to early January.

Seed Germination and Planting Dates

Wild species of meadowfoam differ in the optimum temperature for seed germination (Toy and Willingham, 1966). Most species tested were found to germinate well in the range of 4 to 12°C. Temperatures of 16-27°C during the time the seed imbibed water, caused varying amounts of induced secondary seed dormancy which can persist for several months even after temperatures drop (Toy and Willingham, 1967).

Limnanthes alba displayed secondary dormancy, which increased in frequency with increased duration of exposure of imbibed seed to 27°C temperature. The dormancy persists after the temperature drops; therefore, stand establishment can be severely hindered. *Limnanthes alba* PI 283704 was induced into secondary dormancy at Corvallis, Oregon, by soil temperatures of approximately 18°C. The variety Foamore, which is a selection from PI 283704, has shown reduced levels of secondary dormancy. Dormancy problems associated with high soil temperatures can be minimized by delaying planting until after mid-October in the Willamette Valley. Complete elimination of the dormancy characteristic will allow earlier planting (at higher soil temperatures), so that field operations can be completed before the prolonged fall rains.

Caution should be exercised in planting early in dry seedbeds because light rains may stimulate germination without supplying adequate moisture to support growth until the onset of continuous fall rains.

Spring plantings are difficult because the saturated soils prevent timely planting. Also, substantial yield reductions result from the loss of growth that occurs during November to March in fall-planted crops.

Seeding Rates and Row Widths

Meadowfoam has a growth habit which appears to compensate for substantial variability in seeding rates. Very low seeding rates (5-10 kg/ha) should be avoided because isolated plants grow in a more prostrate manner, which gives a lower canopy height (Table 8) and reduces harvest efficiency. A complete canopy will be formed much sooner with row widths of 4 to 6 cm (or broadcast-

Table 8. The effects of seeding rate on plant canopy height, seed losses at harvest, and total seed yield of *Limnanthes alba* variety Foamore in Corvallis, Oregon (portion of data from Calhoun and Crane, 1978).

Seeding rate	Plant canopy ht. in 1977	Seed loss at harvest (1975)	Total seed yield[1]	
			1975	1977
(kg/ha)	(cm)	(percent)	(kg/ha)	
11.2	25	33.7 a[2]	974 a[2]	510 a[2]
22.4	29	29.4 a	1050 b	529 a
33.6	31	29.2 a	1167 b	409 a
44.8	34	29.8 a	1167 b	342 a

[1] Average of four replications for each year. Total yield includes seed vacuumed from soil surface.

[2] Means followed by the same letter are not significantly different at the 0.05 level of probability.

seeded) than with 16- to 18-cm row widths. The early canopy cover can be advantageous for more light interception and thus more photosynthesis, as well as less soil heat loss and heaving in winter. However, if soil crusting occurs after planting, closely spaced seedlings in a 16-cm row may emerge en masse more readily than equidistant spaced plants. An established stand density of 400 plants/m² spaced equidistant should be attainable with careful planting of high quality seed at 30 kg/ha.

The results of seeding rate trials have been confounded by occasional winter injury, the effects of weather and honeybee pollination on seed set, inconsistent responses to nitrogen fertility, and variable seed shattering.

Plant survival with below-average winter temperatures in Maryland in 1974 was significantly increased as the seeding rate was increased from 11 to 29 kg/ha (Johnson et al., 1980). They did not detect these differences when winter temperatures in 1975 were above average. Thus, planting rates and methods which result in improved ground cover could be expected to have positive plant survival effects in the Willamette Valley in some winters because of reduced heaving.

Seeding rates of 22.4 kg/ha to 44.8 kg/ha have given adequate stands at Corvallis. Canopy height, and thus ease of harvest, increased with increased seeding rates in 1977 (Table 8). There are no reports of significantly reduced seed yields in two or more years from excessively high seeding rates. In 1975, there were no significant differences in the total seed yields of plots seeded at the 22.4, 33.6, and 44.8 kg/ha rates (Table 8). It is not known if the lack of insect pollination limited seed yields. The 22.4, 33.6, and 44.8 kg/ha rates yielded significantly higher than the 11.2 kg/ha rate in 1975. The highest seeding rates did not cause a yield reduction, and the seed was as successfully harvested without loss as at the lower seeding rate (Table 8).

In 1977, the yields of all plots were dramatically lower than in 1975. The 1976-77 crop year was the driest on record at Corvallis. The weather during the flowering period was cool and wet, which resulted in less honeybee pollination and lower seed set.

Seedbed Preparation

The seedbed for planting meadowfoam requires a fineness and firmness midway between that needed for wheat and alfalfa. The seed is small enough to require the fine seedbed for good seed-soil contact, but too fine a seedbed can result in soil compaction and crusting.

Depth of Seed Placement

In the wild, meadowfoam seeds germinate on the soil surface during the rainy season when moisture is abundant and in continuous supply. However, mechanical planting of meadowfoam must be done when the soil is dry enough to support the weight of equipment. Therefore, since the seedling is not adapted to emerge from beneath much soil, the seed should be placed at a depth as near to the soil surface as feasible (3-8 mm) while still being covered, but never deeper than one cm. Proper seed placement prevents seed from moving with free water on the soil surface, and decreases the chance for exposure of the seed and seedling to the more severe loss of moisture at the soil surface.

Fertilization

Meadowfoam seed yields generally have been reduced by applying fertilizer nitrogen. In seven fertilizer trials at Corvallis since 1973, nitrogen fertilizer application at rates of 50-112 kg/ha have never significantly increased seed yields, In four of these years, six of seven nitrogen fertilizer treatments significantly reduced yields (Table 9). Johnson et al. (1980) reported similar results in Maryland.

Three nitrogen sources (calcium nitrate, ammonium nitrate, and ammonium sulfate) were compared at two rates of application (50 and 100 kg N/ha) at two seeding rates (16.8 and 33.6 kg/ha) in 1980. Significant yield reductions from nitrogen application were measured for all sources of nitrogen (Table 10).

Evidence suggests that meadowfoam should not be fertilized with nitrogen. Further research is

Table 9. The effects of nitrogen fertilization on meadowfoam seed yields in eight experiments[1] at Corvallis, Oregon.

Treatment	Total seed yield							
Fertilizer nitrogen	Year							
	1973	1974	1975	1976[2]	1977	1978	1979	1980
(kg/ha)	(kg/ha)							
0 (Check)	1606	853	1534	1186	235	634	750	592
50	1488	...	...	...	178*	590	652*	448*
56	...	875	1429	...	...	...	...	...
67	...	...	...	1077	...	...	...	...
100	1035*	...	...	...	174*	...	...	330*
112	...	803	1348	...	...	...	...	...
LSD_{05}	283	N.S.	N.S.	[2]	39	N.S.	183	61

[1] Individual experiments cannot be compared because of differences in: germplasm, previous crop, soil conditions, seeding rates, nitrogen source, honeybee pollination, and weather.

[2] Split block, random subsampling; LSD comparisons are not appropriate.

* Significantly different from check (0.05 level).

Table 10. The effect of nitrogen and seeding rate on seed yields of *Limnanthes alba* (Sel. 703-A), Corvallis, Oregon, 1980.

Fertility	Seeding rate	
	16.8 kg/ha	33.6 kg/ha
	(kg/ha)	
Check (no nitrogen)	576	608
50 kg/ha N as $Ca(NO_3)_2$	485	438
50 kg/ha N as $NH_4\ NO_3$	463	430
50 kg/ha N as $(NH_4)_2\ SO_4$	437	439
100 kg/ha N as $Ca(NO_3)_2$	375	319
100 kg/ha N as $NH_4\ NO_3$	326	349
100 kg/ha N as $(NH_4)_2\ SO_4$	326	287

LSD (nitrogen) .05 = 60.8 kg/ha
.01 = 83.3 kg/ha
CV = 13.8%

needed to characterize the response of meadowfoam to all fertilizer nutrient elements.

Weed Control

Meadowfoam seed yields are severely reduced by weed competition. Since meadowfoam is well adapted to the poorly drained soils which have grown ryegrass seed in recent years, volunteer annual ryegrass can be expected. Its control, along with that of other weeds, is essential.

Sixty-three herbicides have been tested on *L. alba* at Corvallis. Twenty-three of them have been used at more than one rate or time of application. Only propachlor (2-chloro-N-isopropylacetanilide) and diclofop [2-[4-(2,4 dichlorophenoxy) phenoxy]propanoic acid) provided useful levels of selective weed control. Propachlor applied preemergence at 4.4 to 6.6 kg/ha has given the best broad-spectrum weed control. However, wild mustard and late germinating annual ryegrass infestations can still be a problem in some areas.

Diclofop at 1.12 to 2.24 kg/ha has given excellent postemergence control of annual ryegrass in meadowfoam. The diclofop was applied in March when the meadowfoam and ryegrass were approximately 5 and 20 cm tall, respectively.

Data from two years of field research are shown in Table 11. Three of the treatments were broadcast overseeded with annual ryegrass at 9 kg/ha just before planting meadowfoam. Both herbicides were individually mixed with water and applied as broadcast sprays at 46 liter/hectare.

Table 11. Meadowfoam seed yields as influenced by annual ryegrass competition and the application of propachlor and diclofop.

Treatment	Seed yield	
	1977	1978
	(kg/ha)	
Check (no ryegrass, no weed control)	124	524
Ryegrass[1] (no weed control)	13	193
Ryegrass[1] + propachlor 4.5 kg/ha	263	640
Ryegrass[1] + diclofop 1.12 kg/ha	180	562
Propachlor 4.5 kg/ha	208	634
Diclofop 1.12 kg/ha	—	553
Diclofop 2.24 kg/ha	—	631
$LSD_{0.05}$	43	123

[1] Ryegrass was seeded in the meadowfoam plots at the rate of 9 kg/ha.

The 22.02 inches (559 mm) of precipitation received during the 1976-77 crop year was the lowest ever recorded at Corvallis. Precipitation during May was above normal. Fifteen days were too cold or wet for honeybees to forage during the 22-day flowering period for meadowfoam in 1977 (May 10-June 1). Sixteen days were too wet and cool for honeybee foraging during the 27-day flowering period in 1978. As a result of inadequate pollination and dry soil conditions, the highest meadowfoam seed yields reported in this study are less than half the mean yield of selection 703-A for five previous years at Corvallis.

Ryegrass competition reduced meadowfoam seed yields to 10 percent of the check in 1977 and 37 percent of the check in 1978 (Table 11). Where the overseeded ryegrass was controlled with propachlor or diclofop, seed yields were increased 14- to 20-fold in 1977 and 3-fold in 1978 (Table 11).

In these experiments, weeds which were controlled by diclofop were also controlled by propachlor. However, propachlor controlled mayweed *(Anthemis cotula* L.), little bittercress *(Cardamine oligosperma* Nutt.), common ground-sel *(Senecio vulgaris* L.), and henbit *(Lamium amplexicaule* L.) that were not controlled by diclofop.

In 1977, the ryegrass plus propachlor treatment yielded significantly more than the propachlor alone. The reason for this was not apparent. The ryegrass plus diclofop treatment in 1977 yielded substantially less than either of the above treatments. Again, the reason for this was not apparent. Diclofop treatments at 1.12 and 2.24 kg/ha without ryegrass overseeding in 1978 controlled annual ryegrass without significant yield reduction or noticeable damage to the meadowfoam plants.

Propachlor at 4.5 kg/ha is an effective broad-spectrum selective herbicide on meadowfoam. Diclofop at 1.12 kg/ha gives excellent postemergence control of annual ryegrass in meadowfoam.

There is no registration for commercial use of the above two herbicides on meadowfoam. However, both materials have been widely tested and approved for use on food crops. It is anticipated that the development of a significant meadowfoam market could stimulate interest by herbicide companies to cooperate with university researchers in applying for emergency use permits and possible registration of these compounds.

Insect and Disease Pests

There are no published reports of significant damage to meadowfoam from insect or disease pests. Lattin and West (1979) reported that four of the insects which they collected in and on several varieties of meadowfoam at the Corvallis research station represented potential pests based on their plant associations. These included the spotted cucumber beetle *(Diabrotica undecimpunctata* var. *undecimpunctata)*, a nitidulid beetle *(Meligethes seminulum)*, the seed bug *(Nysius niger)*, and a seed-feeding Carabidae beetle *(Acupalpus meridianus)*. The grey garden slug *(Agriolimax agrestis)* was thought to have fed on young plants in the fall of 1979.

Further research will be needed to determine how particular insects behave in a meadowfoam culture, and the population dynamics associated with the cultivation of commercial fields of the plant. However, meadowfoam culture at Corvallis has not been hindered by insect and disease pests. This is perhaps a benefit of growing a potential new crop which is native to the region.

Pollination

The first experimentation with meadowfoam pollination and seed set at Corvallis was done in 1975. A 9 m^2 area was caged before bloom to exclude insects. Insect population outside the cage was considered to be inadequate for maximum pollination of all the flowers; yet, the seed yield inside the cage was reduced 85 percent from that outside the cage.

In 1976, two 37 m^2 areas (one with nitrogen fertilizer and one without fertilizer) were caged before bloom to exclude insects. Eight hives of honeybees were available for pollination of a total area of 5,500 m^2 outside the cages. Plants outside the cages averaged 2.4 seeds per flower (out of a potential of 5.0); flowers under the cages averaged 0.4 seeds each (Table 12). Even though less than three seeds per flower were set outside the cage, it was speculated that sufficient bees were available for full pollination. However, in a concurrent study, increased honeybee colony density increased seed set (Figure 1). Yet, with 16 colonies of bees per hectare, seed set was only 59 percent.

Table 12. The effects of honeybees and nitrogen fertilizer on seed set of Foamore meadowfoam, Corvallis, Oregon, 1976.

	Number of seeds per flower				
	Sample				
Treatment	A	B	C	D	Mean
Caged 67 kg N/ha	0.29	0.36	0.37	0.30	0.33
Caged 0 - N	0.43	0.48	0.51	0.42	0.46
Un-caged 67 kg N/ha	2.29	2.23	2.14	2.25	2.23
Un-caged 0 - N	2.70	2.61	2.66	2.67	2.66

LSD (0.05) = 0.07 seed/flower
LSD (0.01) = 0.10 seed/flower

A third study helped explain some of the previous results (Figure 2). Meadowfoam pollen collection was highest on the first day of colony exposure to the blooming meadowfoam, and declined with time. Apparently the honeybee is attracted away from the meadowfoam crop. These data would suggest that colony density data alone are not necessarily an indication of pollination activity on meadowfoam, and that it would be necessary to introduce new colonies to a blooming meadowfoam field at 3- to 5-day intervals to maintain a high level of bee activity on the flowers.

It is not known if there is a significant difference in the pollination effectiveness of the honeybees which collect pollen versus the

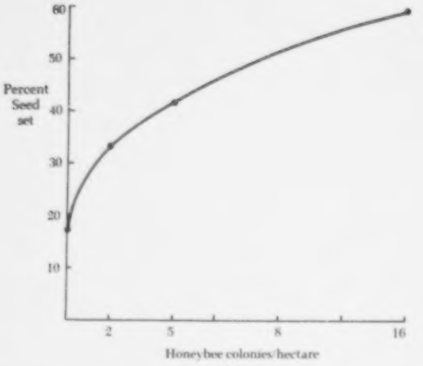


Figure 1. Effect of honeybee colony density on percent seed set in Foamore meadowfoam, Corvallis, Oregon, 1976 (Burgett, 1976).

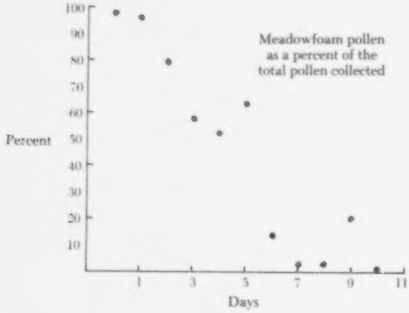


Figure 2. The effect of time after first exposure of honeybee colonies to blooming meadowfoam, on meadowfoam pollen collection, at Corvallis, Oregon, 1976 (Burgett, 1976).

honeybees which collect nectar. No data are available to suggest what is required to guarantee that pollination is not limiting seed set in meadowfoam. Additional research of this type may be necessary to gain an accurate understanding of the interactions of honeybee pollination and seed yield in meadowfoam.

Harvesting

Production of meadowfoam on a commercial scale requires mechanical harvesting. Native meadowfoam is not well suited to mechanical harvesting because it tends to be short in stature with a prostrate growth habit and its seed shatters before the plant reaches harvest maturity.

Improved meadowfoam lines have been successfully harvested on a farm-scale basis in 1980. The crop was cut with a windrower when approximately 90 percent of the seeds were judged to be physiologically mature (accumulated maximum dry matter). Windrowing was done when the meadowfoam stems were green enough to be pliable, and early in the morning when dew minimized the shattering of mature flowers. Care was exercised at all times to avoid causing seed shatter. Virtually no shattering occurred during the swathing operation.

The combine harvest (John Deere 7200 turbo), using a windrow-pickup attachment, followed windrowing by 13 days (3-5 day delay because of rain). The combine was equipped for orchardgrass and ryegrass seed harvest. The threshing was accomplished by operating the machines as follows: ground speed, 1.7 km/hr (slowest setting); cylinder, 7 sets of teeth and 1,200 rpm (maximum speed) at the closest cylinder clearance possible; fan, 600 rpm, and both sieves completely open. The loss of meadowfoam seed through the combine was measured in one sample (8 kg/ha). More research is needed to refine the techniques of harvest, but no serious harvesting problems are apparent.

MEADOWFOAM SEED MEAL — A FEEDSTUFF

The economic potential of producing meadowfoam as a crop would be increased if the extracted meadowfoam meal (MFM) were useful as a feedstuff for domestic livestock. Throckmorton et al. (1981a) and Throckmorton et al. (1981b) have evaluated MFM as feedstuff for broiler chicks and weanling rabbits, and sheep, respectively.

Poultry and Rabbits

Three experiments were conducted to evaluate meadowfoam meal (MFM) as a feedstuff for broiler chicks and weanling rabbits. In Experiment 1, chicks were fed diets with 30 percent of the dietary protein supplied by raw, steam-cooked (SC), SC plus 3 percent sodium carbonate (SC +), or aqueous acetone extracted (EXT) MFM. Weight gains and feed efficiency were severely depressed (P< 0.01), with 60 percent mortality for birds fed the raw MFM, primarily because of refusal to consume the diet. Performance of other treatments was similar to the control. Liver and thyroid weights at 6 weeks were increased (P<0.01) on SC and SC+ MFM diets, but organ weights on EXT-MFM were similar to controls. In Experiment 2, chicks were fed diets in which SC-MFM isonitrogenously replaced 50 percent of the soybean meal in the control diet. Treatments were dietary additions of iodine, iodinated casein, and lysine. Weight gains and feed efficiency were reduced (P<0.01) on all diets containing SC-MFM. Performance on SC-MFM without dietary additions varied less than 0.5 percent between Experiment 1 and 2. Liver weights were increased (P<0.01) on all diets containing SC-MFM, and thyroid weights were increased on all treatments (P<0.01) except for the iodinated casein addition, indicating that iodinated casein was effective in overcoming the goitrogenic effect of MFM. In Experiment 3, weanling rabbits were fed diets in which raw MFM replaced 25 and 50 percent and SC-MFM replaced 25, 50, 75, and 100 percent of the alfalfa and soybean meal in the control diet. These levels corresponded to 20, 40, 60, and 80 percent of the dietary protein being supplied by MFM. Weight gains were similar to controls when SC-MFM was added at the 25 and 50 percent replacement level, but decreased 12 and 29 percent (P<0.05) at the 50 and 75 percent levels. Performance was very poor at the 100 percent replacement level because of a reluctance to consume the diets. At the 25 and 50 percent replacement levels, raw MFM decreased weight gains by 18 and 26 percent (P<0.05) compared to controls. The results suggest that rabbit performance is also improved by steam-cooking MFM, although the differences between raw and SC-MFM were not as dramatic as in broiler chicks. In short term feeding trials, SC-MFM appears to be a satisfactory feedstuff for broiler chicks and weanling rabbits when incorporated at moderate dietary levels.

Lambs

Four experiments were conducted to evaluate MFM as a feedstuff for sheep. In Experiment 1, a digestion trial with lambs, comparing raw and steam-cooked (SC)MFM with cottonseed meal (CSM), indicated that raw MFM reduced (P<0.01) the apparent digestibility of energy, dry matter, crude protein, acid detergent fiber, and ash by 4, 6, 8, 52, and 55 percent, respectively. Steam-cooking caused additional (non-significant) reductions of all values except fiber and ash. In Experiment 2, a growth trial with lambs, comparing diets in which raw MFM replaced 50 or 100 percent of the CSM in the control diet, there was no reduction in weight gain or feed efficiency at either replacement level. In Experiment 3, a finishing trial comparing MFM and CSM as the supplemental protein source, there were no differences in weight gain or feed efficiency, but a slight improvement in dressing percentage (P<0.05) on the MFM diet. Thyroids, livers, and kidneys from these lambs were histologically evaluated. In Experiment 4, ewes which consumed raw MFM during the last 7-9 weeks of pregnancy showed no differences in serum thyroid hormone values compared to controls. However, one ewe gave birth to a lamb with definite goiter after 9 weeks on the MFM diet. The results of these experiments indicate that raw MFM is a satisfactory feedstuff for growing lambs when used at moderate levels, but should not be fed to pregnant ewes until further research can resolve the question about goiter in newborn lambs.

SUMMARY

Meadowfoam's adaptation to wet lands in the mid- to southern Willamette Valley makes it an attractive potential new oilseed crop. The unique composition of the oil has led to suggestions that its utility in the industrial oil market could become economically profitable. Domestication and agronomic development for commercial scale production have been accomplished at Oregon State University. The oilseed meal can be used in certain feedstuff applications.

Additional research and development are needed in nearly all aspects of meadowfoam development. Special attention is needed for increasing seed yields, and oil utilization research to capitalize on its unique composition.

Historically, the methods and rates of crop development have been generally unpredictable. There is no evidence to suggest that it will be different for meadowfoam.

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Meadowfoam:

New source of long-chain fatty acids

Meadowfoam, a wildflower native to the Pacific Coast of North America, is seen by the Oregon Meadowfoam Growers Association as an alternate domestic source of industrial long-chain fatty acids. Recent efforts in the Pacific Northwest have focused on cultivating meadowfoam and promoting usage of the oil. In this article, Richard H. Purdy, technical consultant from Novato, California, and Charles D. Craig, program coordinator for the Oregon Meadowfoam Growers Association, review the history, current status and outlook for meadowfoam as a commercial crop. The address for the Oregon Meadowfoam Growers Association is 866 Lancaster Drive S.E., Salem, Oregon 97301.

Meadowfoam is a low-growing herbaceous winter annual wildflower native to the Pacific Coast of North America. The name "meadowfoam" was derived from its beautiful canopy of creamy white flowers at full bloom. Although one species of the genus was taken to England and grown as an ornamental in the 1800s, its potential industrial importance was not recognized until 1959, when U.S. Department of Agriculture (USDA) scientists at the Northern Regional Research Center in Peoria, Illinois, were searching for new raw materials from native American plants. The value of meadowfoam oil was apparent immediately because of its unique composition of fatty acids, over 95% of which have chain lengths of 20 carbon atoms or longer (1).

Commercial meadowfoam oil's fatty acid distribution is compared with those of rapeseed and crambe oil in Table 1. Meadowfoam oil has over 35% more long-chain fatty acids than rapeseed oil and 25% more than crambe oil. Its content of methylene interrupted diene (linoleic acid), essential for oxidative stability in industrial products, is significantly low. The high level of monoene is predominated by the unusual Δ5 double bond position, which also is present in the nonmethylene interrupted Δ5,13 diene. Pollard and Stumpf (2) have studied the biosynthesis of these unique fatty acids in the developing meadowfoam seeds.

Seed development

Meadowfoam seeds are pear-shaped, consisting of a thin brown striated hull surrounding a relatively soft, light-colored dicotyledon kernel. The seeds, measuring about 2 × 3 mm, average 150 to the gram. The kernels contribute about two-thirds of the total weight and contain

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(Photo courtesy of Gary Jolliff, Department of Crop Science, Oregon State University, Corvallis, Oregon)

TABLE 1

Typical Compositions of Long Chain Fatty Acid Sources

	Meadowfoam	Rapeseed	Crambe
18:1	2	17	15
18:2	0.5	14	8
18:3	–	7	4
Other < C:20	1	3	3
20:0	0.5	0.5	1
20:1 (Δ5)	62.5	–	–
20:1 (Δ13)	–	9	4
22:1 (Δ5)	2.5	–	–
22:1 (Δ13)	12	48	59
22:2 (Δ5, Δ13)	18	–	–
Other > C:18	0.5	0.5	6
Total C:20 +	96.5	60	70

essentially all of the oil. Commercial meadowfoam produced during 1985 and 1986 contained about 27% oil, although oil contents as high as 35% have been attained in experimental test plots.

In the early 1960s, field trials, germ plasm accessions and agronomic evaluations at a variety of locations concluded that the Willamette Valley of Oregon provided the perfect conditions for seed production (3). The species *Limnanthese alba*, variety *alba*, appeared to have the best potential because of superior seed retention, upright growth and plant height. Experimental yields were sufficient to suggest promise as a new oilseed crop.

The Oregon State Agricultural Experiment Station in 1967 initiated a crop improvement and agricultural production program. In 1980, this program showed an increased level of effort as a result of funding from the Oregon grass seed industry, which was searching for alternative crops to grass seed for the poorly drained soils of the Willamette Valley and for a way to lessen the pollution resulting from field burning required after harvesting. Two cultivated meadowfoam varieties were released by the agricultural station, including "Mermaid" which was released exclusively as a proprietary variety to the Oregon Meadowfoam Growers Association. This variety is currently the only known variety in commercial production.

Thirty-five acres planted in 1979 resulted in the production of 2,000 pounds of greenish black oil. Samples were provided to industry under contract by an Oregon wood products firm. The poor quality of the oil, its high price and lack of availability sharply limited interest. However, meadowfoam intrigued the Japanese cosmetic industry and its industrial potential promised by its long-chain fatty acid composition sustained development activity.

Extraction and refining

The first attempt at commercial production of meadowfoam oil was by full expeller pressing. Unfortunately, yield was considered more important than quality during the operation, resulting in an oil very difficult to clean up but acceptable to the Japanese. Less yield-efficient expeller pressing using a small Hander EX-100 unit required only pretreatment with phosphoric acid and activated bleaching earth, followed by physical refining, to attain a color of 0.3 lovibond red. About 1,000 pounds were produced using pilot plant equipment for sampling potential customers.

Evaluation of extraction techniques, comparing pre-press/hexane extraction and direct hexane extraction with and without prior extrusion, was conducted at the Texas A&M Engineering Experiment Station using a 4.5-inch Anderson extruder and a one ton/day pilot Crown continuous extractor. The data indicated that direct extraction with prior extrusion was feasible based on meal oil content residuals of less than 1%. Extracted oil quality from all three processes required phosphoric acid pretreatment prior to alkali refining, and the use of carbon and activated bleaching earth to achieve less than 1.0 lovibond red colors after deodorization.

Commercial seed and oil production

Approximately 250 tons of meadowfoam seed harvested in 1985 and 1986 were crushed in October 1986 by direct solvent extraction using the extruder for seed pretreatment. Residual oil contents of less than 2% in the meal were attained. This was considered quite satisfactory for such a short run. Oil quality, as judged by laboratory refining, was comparable to the pilot plant crude extract.

The resulting 135,000 pounds of crude oil were phosphoric acid pretreated, alkali-refined, vacuum bleached with activated clay and carbon, and deodorized, yielding approximately 125,000 pounds of oil with 0.7 lovibond red color, 0.03% free fatty acid and bland flavor and odor.

Oil characteristics

Commercially extracted crude oil (Table 2) is very dark with a heavy black muscilagenous sludge settling out during storage. The amount and nature of the phosphatides have yet to be determined, but probably could be estimated at 1 to 1.5% based on the difference between the neutral oil loss and the free fatty acids, moisture and impurities.

The crude oil free fatty acids are relatively low, as might be expected of longer carbon chain fatty acid triglycerides and the rather intact seed coat. An 0.8% value was obtained from extracted 1985 and

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1986 harvested seed, half of which had been stored for over a year. Oil pressed from recently harvested seed usually runs less than .5%. Both density and viscosity parallel the fatty acid composition.

Refined meadowfoam oil remains clear and liquid at refrigeration temperatures, probably because of the melting point depressing effect of the 18% dieonic fatty acid. However, the non-methylene interrupted C-22, Δ5, 13 diene acts more like a monoene with regards to oxidative stability as evidenced by the unusually high activated oxygen method (AOM) value attained after deodorization.

The tocopherols in commercial crude and deodorized meadowfoam oils have been analyzed (Personal communication, Robert R. Lowry, Oregon State University, May 1987). The predominate tocopherol in crude oil is gamma tocopherol, at 0.05%. Alpha and beta tocopherols contribute an additional 0.01% each. Commercial deodorization reduces the gamma isomer by about 40%.

Meal characteristics

The somewhat low protein (25%) and high fiber (22%) levels of meadowfoam meal, in addition to its glucosinolate content, suggest utilization problems. Although somewhat low in methionine, the amino acid distribution (Table 3) very closely parallels those of rapeseed and crambe meals, with quite satisfactory levels of lysine. The glucosinolate level of 105 micromoles/gram (about 4%) is three to four times the level defined for low glucosinolate canola meal, but lower than crambe meal. About 90% is meta-methoxyl benzyl glucosinolate and the remainder is primarily 2-hydroxy-2 methyl propyl glucosinolate.

Feeding trial data are limited. However, Throckmorton (4) at Oregon State University reported that even raw uncooked meal is a satisfactory protein supplement for sheep and was accepted readily when added as a top dressing in a basal diet. He recommended it not be fed to pregnant ewes and newborn lambs until further studies relative to goiter problems are conducted.

TABLE 2

Analytical Characteristics of Meadowfoam Oil

	Crude	Deodorized
Free Fatty Acids, %	0.8	0.03
Moist. & Imp.	0.2	nil
Color, Gardner	dark	2
Unsaponifiable, %	–	0.2
100 - Neutral Oil, %	2.4	–
Viscosity, cp @ 25 C	–	85
Density, g/ml @ 25 C	–	0.907
Cloud Point, °C	–	4.5
AOM, hr	–	150-200

Throckmorton's study with growing rabbits and broiler chicks (5) indicated "steam cooked" meal (presumably equivalent to desolventized-toasted meal) was satisfactory. Feeding trials using the 1986 commercial meal with rabbits involving several sequential litters of the same parent animals are in progress. No abnormalities have been observed after the first litter (Personal communication, Peter Cheeke, Oregon State University, August 1987).

Oil utilization

Utilization research on meadowfoam oil has been limited. Studies at the USDA laboratories in Peoria have explored lubricant uses, with emphasis on the preparation and evaluation of liquid wax esters and their sulfurized products (6). Hydrogenation of the triglyceride yielded a high melting point product comparable to carnauba and candelilla (7). Comparisons with other sulfurized vegetable oil triglycerides indicated meadowfoam derivatives to be superior as lubricant additives (8).

Meadowfoam oil fatty acids are liquid at room temperature as are the alcohols. The isopropyl ester exhibits a very low cloud point

TABLE 3

Amino Acids in Meadowfoam Protein

	(g/16 g Nitrogen)		
Cysteine (half)	1.1	Lysine	5.1
Tyrosine	2.6	Arginine	7.4
Glycine	6.2	Methionine	1.3
Serine	3.9	Histidine	2.4
Alanine	4.0	Threonine	3.1
Aspartic acid	7.8	Leucine	6.4
Glutamic acid	16.4	Isoleucine	3.3
Proline	4.3	Valine	4.2
Ammonia	2.6	Phenylalanine	3.9

(−17 C) and low viscosity (10 cp at 25 C) and appears to be of interest to the cosmetic industry because of its "dryness" or very rapid adsorption into the skin. The mono/diglycerides (40% mono-) are semisolid at room temperature, but remain liquid for several days after melting, as opposed to distilled monoglycerides (90% mono-), which crystallize rapidly. The propylene glycol ester is a soft gel. These products should demonstrate unique functionality in many applications based on the long carbon chain length of their fatty acids.

Industrialization in the private sector has been inhibited by poor quality oil samples, lack of availability and acceptable prices. However, a recent survey of the ten most promising new crops estimated an overall demand for more than 100 million pounds of meadowfoam oil annually, if prices could be achieved in the 50-cents-per-pound range (9).

A credible and reliable production management and marketing organization exists. Successful routine commercial-scale extraction and refining have been accomplished. High value specialty uses such as cosmetics are increasing. Advances in crop production technology and cultivar yield improvement are currently in process on a modest scale, with a 50% yield increase likely within the next two years. A proposal to accelerate the commercial development of meadowfoam through an intensified cultivar development and comprehensive industrial utilization study involving a three-way state, federal and industry-funding mechanism appears to be receiving favorable review. The overall objective of this program is to make meadowfoam oil available for 50 cents per pound within the next five to ten years.

No serious biological barriers have been identified that would impede rapid progress toward this goal.

ACKNOWLEDGMENTS

Derivatives were prepared and analyzed by Capital City Products Co., Eastman Chemical Products Inc., Emery Chemicals, Lonza Inc. and Sherex Chemical Co. Inc. Amino acids were determined by F.W. Sosulski, University of Saskatchewan. Glucosinolates were determined by R. Auld, University of Idaho. This project was supported by the Oregon Department of Economic Development with funds from the Oregon Lottery.

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Senator **Conrad**. Thank you. This is just excellent testimony. It seems so obvious and so clear, does it not, that we need a vehicle like this, and that we have just got to start down this road. And we are not talking about some extraordinary allocation of funds.

We understand the context within which we are operating, but in terms of the national interest, it seems so readily apparent that this is an effort that we ought to embark upon. I want to publicly commend and thank both Dr. Blase and Dr. Jolliff for their involvement in the task force because it really is the work of the task force that we have attempted to embody in this bill.

I would be the first to say that there are things we can do to improve it. We have heard, I think, absolutely excellent suggestions from Dr. Blase and from Dr. Gage and Mr. Aube on things we can do to improve it, and we will certainly do those things.

But it is my hope that we can somehow summon up the political will to engage in some new thinking. It just seems to me so absolutely clear that that is what the situation requires. We just cannot keep digging the rut deeper.

I want to thank you also, Dr. Jolliff. I remember being very impressed by the testimony that you provided earlier when you and others came forward with the work that the task force had done.

I must say it was the persuasive work that you and others have done that convinced me that we had to go forward with legislation like this. And we have made some progress. There are more hurdles to jump here. For example, you know we had a tentative agreement to put this legislation in the Rural Development bill, and now I understand we are back to arguing with some about whether it should be included or not.

I think it is just fundamental that this legislation be included. Now we are back to that being jeopardized, which, to me, would just be a tragedy given the opportunity that is in front of us.

Well, again, the testimony that you have provided is going to help us win this battle. We will win this battle because it needs to be fought, and it needs to be won.

I would like to go forward with Mr. Scott Shearer, executive director of the National Corn Growers Association, and then come back to some questions for him as well. Scott, welcome, and proceed.

STATEMENT OF SCOTT SHEARER, EXECUTIVE DIRECTOR, NATIONAL CORN GROWERS ASSOCIATION, ST. LOUIS, MO

Mr. **Shearer**. Thank you, Mr. Chairman. I appreciate the opportunity of testifying today on S. 2413. I will summarize my testimony and address three areas. The changes that have taken place in the corn industry in the last 20 years; efforts by the National Corn Growers Association in finding new uses and new markets for corn; and the importance of S. 2413.

CORN INDUSTRY BACKGROUND

If we look at the corn industry in the last 20 years, there have been dramatic changes taking place. Nearly 80 percent of the total corn used 20 years ago was for livestock and poultry feed. Today feed usage has declined to half of total utilization, that is at 50 percent.

Because of production technology our yields have doubled in the last 20 years.

There is 12 million acres more of corn harvested now than 20 years ago. And even though food, seed, and industrial use was stagnant in the 1960's, it has doubled in the last 10 years because of ethanol and corn sweeteners.

Exports have declined dramatically in the 1980's. As the result of many of these changes in the corn industry, carry-over stocks of corn have gone from 30 percent in 1964 to 6 percent in 1975 to today nearly 50 percent.

The decade of the 1980's has been very difficult for American agriculture. However, we need to recognize our tremendous capacity to produce agricultural commodities or renewable resources offers us the potential of developing new uses and new markets.

NEW USES AND NEW MARKETS FOR CORN

The National Corn Growers Association has made a long-term commitment to developing new uses and new markets for corn. While growth in the established markets, exports, animal feeds, ethanol and sweeteners, is encouraging and important, vast new industrial uses offer even more hope for the future.

In June of last year, the first National Corn Utilization Conference was held in St. Louis, MO and was sponsored by the National Corn Growers Association.

The primary message from that conference was anything made from a barrel of petroleum can be made from a bushel of corn.

There are many potential new uses for corn. I would like to bring you up to date on two: biodegradable plastics and calcium magnesium acetate.

BIODEGRADABLE PLASTICS

Many local and State governments are facing a crisis regarding solid wastes. The U.S. Conference of Mayors estimates that half of the American cities will be out of landfill space in the next 10 years. It is estimated that the Chicago metropolitan area has 4 years remaining and New York City has 5 years left in its landfill. Plastics represent as much as 10 percent by weight and 40 percent by volume of solid wastes buried in our landfills.

It is here, the plastics segment of solid wastes, where agriculture can be a part of the solution. Degradable plastics, a blend of corn starch and synthetic polymers, may be one solution. This plastic bag put out by the North Dakota Corn Growers Association contains 6 percent cornstarch which is added to the plastic along with the oxidant, which can be corn oil, to render common plastics biodegradable. It is estimated that this plastic bag buried in a landfill will be gone in 3 to 5 years.

The city of Lincoln, Nebraska and the Nebraska Corn Development, Utilization and Marketing Board have joined together in a biodegradable plastic demonstration project. Last week, 1,400 residents of Lincoln, Nebraska were asked to place their yard waste in these specially marked biodegradable bags that contain 6 percent cornstarch. These bags containing yard waste will then be processed into compost, which will allow more efficient use of the city's new landfill site.

If this project was used for all of Lincoln's yard waste, it is estimated biodegradable bags could potentially save the city $100,000 in labor costs and lengthen the life of the landfill.

Last month in Page, Arizona, the Salt River Project, an Arizona power and water utility, sponsored its annual cleanup project. This year, the volunteers were using cornstarch based biodegradable plastic garbage bags to clean up the area around Lake Powell. Half a million bags will be distributed this year in Arizona with a logo on the bags indicating they are degradable—made with corn, a renewable resource.

Thus, we feel that the biodegradable garbage bag is the first step in offering a solution to our landfill problem. We also need to look long term at developing other degradable plastic products where applicable. Plastic products, such as milk jugs and other containers, and this plastic bottle here that research is being done contains 6 percent cornstarch.

Senator CONRAD. So this would be biodegrade as well even though it is plastic?

Mr. SHEARER. In 3 to 5 years if buried in a landfill, correct. And developing other degradable plastic products where applicable. Additional research needs to be continued to improve and expand the use of cornstarch in many plastic products that we use.

It is estimated that potentially a 300 million bushel corn market could be created through the use of degradable plastics. Some estimates are even higher than that, Mr. Chairman.

Another product is calcium magnesium acetate.

Senator CONRAD. Say, does wheat work in this?

Mr. SHEARER. No. [Laughter.]

But there are other possibilities that some are using looking at starch from the sugar and even corn sweetener. So there is some potential there.

CALCIUM MAGNESIUM ACETATE (CMA)

Annually we use close to 10 million tons of salt for highway deicing. However, salt has detrimental effects of corrosion, and damage to road surfaces, vegetation, and water supplies.

One alternative to salt is calcium magnesium acetate or CMA. Most of the studies indicate that CMA performs as well as salt, but is 10 times less corrosive, has little detrimental effect on vegetation and wildlife, and does not lower water quality. The drawback is it costs about 10 times as much as salt.

CMA can be produced either using petroleum or corn as the feedstock. However, additional research is needed on production, testing, economic analysis, and market development.

These are just two examples of the many efforts that the NCGA are working on to use our renewable resource—corn—to help solve environmental problems facing our Nation while at the same time providing a new market for corn.

AGRICULTURAL RESEARCH COMMERCIALIZATION ACT OF 1988

New product development and market introduction is long, arduous, and expensive process. It requires commitment, discipline, and persistence. The Agricultural Research Commercialization Act of 1988, S. 2413 is a major step forward in this effort.

This legislation provides for a long term and consistent national commitment in the development of new agricultural products for industrial uses. It provides for a means to take our research and technology from the laboratory to the marketplace. The revolving fund provides a long-term source of funding for cooperative, private and public programs.

The development of new industrial uses and markets for our renewable resources, agricultural products, will provide for a viable agricultural economy in the future. It will also help establish new industries, employment, economic activity for our communities, and hopefully increase tax base for government, and it will also help us to be competitive in the world marketplace.

Mr. Chairman, the National Corn Growers Association commends you and the other cosponsors of this legislation. We support this legislation and are willing to assist in your efforts.

[The prepared statement of Mr. Shearer follows:]

Testimony of Mr. Scott Shearer
Executive Director of the National Corn Growers Association
Before the Subcommittee on Agricultural Research, and
General Legislation of the Senate Committee on
Agriculture, Nutrition, and Forestry

Mr. Chairman, members of the Committee, I am Scott Shearer, Executive Director of the National Corn Growers Association. I appreciate the opportunity of testifying today on S. 2413, the "Agricultural Research Commercialization Act of 1988". My comments will address three areas: (1.) changes that have taken place in the corn industry; (2.) efforts by the National Corn Growers Association in finding new uses and new markets for corn; and (3.) the importance of S. 2413. .

Corn Industry Background

During the past 20 years, the corn industry has changed dramatically. Nearly 80 percent of the total corn used 20 years ago was for livestock and poultry feed. Today feed usage has declined to half of total utilization.

Improved production technologies have resulted in average yields nearly doubling in the last 20 years.

Harvested corn acreage has increased from 63 million in 1964 to a high of 75.2 million in 1985.

During the 1960's, food, seed, and industrial (FSI) usage of corn remained fairly constant. But in the past 10 years FSI usage has more than doubled. The development of the ethanol industry and the growth in corn sweeteners has made this possible.

Twenty years ago exports were relatively stagnant until the growth years of the seventies. But our agricultural exports have declined dramatically since 1981. This was caused by several factors, including effects of embargoes, a strong dollar, foreign debt, increased foreign competition, and worldwide economic recession.

As a result of many of these changes in the corn industry, carry-over stocks have gone from 30 percent in 1964 to a low of 6 percent in 1975 to nearly 50 percent today.

The decade of the eighties has been very difficult for American agriculture. However, we need to recognize our tremendous capacity to produce agricultural commodities or renewable resources, offers us the potential of developing new uses and new markets. This will help provide for a strong viable agricultural economy.

New Uses and New Markets for Corn

The National Corn Growers Association (NCGA) has made a long-term commitment to developing new uses and new markets for corn and corn products. While growth in the established markets, exports, animal feeds, ethanol, and sweeteners, is encouraging and important, vast new industrial uses offer even more hope for the future.

In June of last year, the first National Corn Utilization Conference was held in St. Louis, Missouri. The conference sponsored by the NCGA brought together over 250 scientists, researchers, industry specialists, and producers for a closer look at the potential for new industrial uses for corn.

The primary message: anything made from a barrel of petroleum can be made from a bushel of corn.

There are many potential uses for corn. I would like to bring you up to date on two: biodegradable plastics and calcium magnesium acetate.

Biodegradable Plastics

Many local and state governments are facing a crisis regarding solid waste. Annually, 150 million tons of municipal solid wastes are generated nationwide. Ninety percent of our urban waste is buried. The U.S. Conference of Mayors estimates that half of the American cities will be out of landfill space in ten years. It is estimated the Chicago metropolitan area has four years remaining and New York City has five years left in its landfill. In 1960, the average American produced 2.9 pounds of garbage per day. Today, it has increased to 5 pounds per day. In 1985, there were 75 million tons of waste in throwaway containers that did not exist 40 years ago. Plastics represent as much as 10 percent by weight and 40 percent by volume of solid wastes buried in our landfills.

It is here, the plastics segment of solid wastes, where agriculture can be part of the solution. Degradable plastics, a blend of corn starch and synthetic polymers, may be one solution.

At the six percent level, corn starch can be added to plastic along with an oxidant, which can be corn oil, to render common plastics biodegradable (such as garbage bags) without any drastic reduction in physical characteristics. Once in contact with the biological media -- initially fungi and then bacteria -- in soil or water, the corn starch granules are consumed. This opens up and weakens the matrix of the material. Then the oxidant, corn oil, in contact with the metal salts (copper, iron) in the environment forms peroxide, which breaks down the long polymer chains. Once these carbon chains are shortened, they become a food source for biological activity. It is estimated that in a landfill one of these plastic bags would be gone in three to five years. As these bags degrade much faster than the current conventional garbage bags, the wastes contained in the bag also decompose that much faster.

The city of Lincoln, Nebraska and the Nebraska Corn Development, Utilization and Marketing Board have joined together in a biodegradable plastic demonstration project. Last week, 1,400 Lincoln residents were asked to place their yard waste in specially marked biodegradable bags that contain six percent corn starch. These bags containing yard waste will then be processed into compost, which will allow more efficient use of the city's new landfill site.

If this project was used for all of Lincoln's yard waste, it is estimated biodegradable bags could potentially save the city $100,000 in labor costs and lengthen the life of the landfill.

Last month in Page, Arizona, the Salt River Project, an Arizona power and water utility, sponsored its annual clean-up project. This year, the volunteers were using corn-starch based biodegradable plastic garbage bags to clean up the area around Lake Powell. Half a million bags will be distributed this year in Arizona with a logo on the bags indicating they are degradable -- made with corn, a renewable resource.

Thus, we feel that the biodegradable garbage bag is the first step in offering a solution to our landfill problem. We also need to look long term at developing other degradable plastic products where applicable. Plastic products, such as milk jugs and other containers, are currently in the experimentation stages to be made biodegradable. Additionally, research needs to be continued to improve and expand the use of corn starch in the many plastic products we use. It is estimated that potentially a 300 million bushel market for corn could be created through the use of degradable plastics.

Calcium Magnesium Acetate (CMA)

Annually we use close to 10 million tons of salt for highway de-icing. However, salt has detrimental effects of corrosion, and damage to road surfaces, vegetation, and water supplies.

One alternative to salt is calcium magnesium acetate (CMA). Most of the studies indicate that CMA performs as well as salt but is 10 times less corrosive, has little detrimental effect on vegetation and wildlife, and does not lower water quality. The drawback is it costs about ten times as much as salt.

CMA can be produced using either petroleum or corn as the feedstock. However, additional research is needed on production, testing, economic analysis, and market development.

It is estimated if CMA made from corn captured 10 percent of the highway salt market, this would mean a 60 million bushel corn market annually.

These are just two examples of the many efforts that the NCGA are working on to use our renewable resource - corn - to help solve environmental problems facing our nation while at the same time providing a new market for corn.

Agricultural Research Commercialization Act of 1988

New product development and market introduction is a long, arduous, and expensive process. It requires commitment, discipline, and persistence. The "Agricultural Research Commercialization Act of 1988" is a major step forward in this effort.

This legislation provides for a long term and consistent national commitment in the development of new agricultural products for industrial uses. It provides for a means to take our research and technology from the laboratory to the market place. The revolving fund provides a long term source of funding for cooperative private and public programs.

The development of new industrial uses and markets for our renewable resources, agricultural products, will provide for a viable agricultural economy in the future. It will also help establish new industries, employment and economic activity for our communities. And it will also help us to be competitive in the world market place.

Mr. Chairman, the National Corn Growers Association commends you and the other co-sponsors of this legislation. We support this legislation and are willing to assist in your efforts.

Senator CONRAD. Boy, I tell you that is great news because we really do think that this is positive. You know, as we look over the horizon and we see the many challenges in agriculture, we realize that if there was ever a time that we really have a need to have some innovative thinking, this is the time.

I want to give the credit where credit is due. The task force came up with the new thinking. They are the ones that came up with this idea. We simply recognized it as being a good idea and are trying to promote it and implement the good thoughts that are there.

I think one of the things that is most frustrating about this place is when you see something that is absolutely obvious, we somehow let it slip through the cracks. I had my concentration and my attention diverted for a moment because I am just having to enter my floor statement on the budget that we are about to pass, which is another great example of a failure to deal with what is obvious.

It is obvious we have to do something about the deficit. Yet we do nothing. It is obvious that we have to do something about what is in front of us here. I deeply appreciate the work you all have done. The Corn Growers also participated in the work of the task force.

I think it was exceptionally good work. I think we ought to implement that work. I am committed to it. I am going to work very hard, along with my staff and the others who are participating in this effort, to actually get this to be the law of the land. We desperately need your assistance.

It is my intention to contact every member of the task force after we have gone back and strengthened this legislation because I am convinced, based on what I have heard today, there are a whole series of things that we can do that will make it better, more flexible, take into account the changes in Board size as well as Board structure, and also improve the flexibility of what the Board can actually do. Awfully good suggestions were made here today.

Then we will have a final product that we can all enthusiastically back. I would just like to ask you, Scott, about one of the hurdles of marketing these plastic bags. This has been an idea that has been around for awhile, has it not?

Mr. SHEARER. That is correct. I think there is a major point we need to look at in agriculture. There is a saying, "those who do not understand history are doomed to repeat it." We had tremendous surpluses in the 1950's and 1960's, and we started talking about utilization research. And much of what has been talked about has been around for a long time.

In the 1970's, because of the tremendous boom in the export markets, utilization research was put on the back burner. Now it is being brought forth again in the time of the 1980's, and so we need to put this national commitment together now.

Otherwise, and it is dry in many areas of the country, and if the crop is down and exports pick up and exports are important, this will go back to the shelf again. And we will wait till the next time. So we need to have this long-term commitment. And I think that is the important thing.

The other aspect is, you are right, that biodegradable plastics are not new. Its been around. It is now coming forth to help solve some problems, but there are other things that I am afraid that are probably on the shelf that if we could bring it forth. Because you not only hit the barriers sometimes of government but also the barriers in the private sector of industry and tradition and things of that type. And so that needs to be done.

Senator CONRAD. It really is history repeating itself.

Mr. SHEARER. Yes.

Senator CONRAD. I do not know how many researchers and people who have been involved in business who have come to my office and said, Senator, you know, here is an example of what the task force was talking about. I had the hearing last year, and they have heard about it some way, and have come to me and said—here is another example of where we have something on the shelf which ought to be commercialized.

If we were in Japan, it would have been commercialized. Yet here we have Japan which has benefited tremendously from our basic research. We seem to be just asleep at the switch with respect to commercializing the work we have done ourselves.

It is frustrating, and it is counterproductive because the Japanese, who I want to commend, have seized on these things. They have figured this out, and they have adopted structures much like this to commercialize basic research done in this country.

Yet here we sit, doing the same old thing and wondering why we are not doing as well as we might. Dr. Jolliff, I wanted to go back to you because you have talked about some other areas in which research has been done. Things that are on the shelf and have not been pursued as aggressively as they might have been.

I just ask you to comment on and analyze perhaps, in some of these other crop areas, what are the significant barriers that are faced in getting the other crops that you have identified here today commercialized?

Dr. JOLLIFF. Well, let us take pyrethrum. Did you want me to skip over meadowfoam?

Senator CONRAD. No, I think I know that story, but if you would give us the pyrethrum story.

Dr. JOLLIFF. OK. Pyrethrum, I think, is a case where we needed the ability to put the management and capital investment and the research together as a package that some of the previous testimony has alluded to.

The way that came in was a person with an idea in California that was a chemical process engineer learned about high pressure CO_2 extraction which I think was developed largely in one of the USDA labs. I cannot verify that.

But he saw that as a way to get concentrated pyrethrum, the insecticide, out of the flower. So that was a new technology, and then he learned of a tea leaf harvester that was a mechanism in Australia. He put those things together and went back to the literature and saw that the U.S. Navy did pyrethrum research here in the 1930's or 1940's, in the war years, because we needed it.

And so he put all that together and looked at how much we were importing, and seeing about the possibility of getting a natural insecticide to help eliminate some of the synthetic chemicals in all the agricultural uses, and began to try to launch out on that on his own.

Well, it was a bigger job than I think what he realized. Pretty soon he was looking for a venture capitalist, and he found one. But it just was not enough to bring it all together and keep it together long enough to get it economic and launched.

I am sure there were management decisions along the way that could have certainly benefited by this team, this expertise that has been described earlier. In the case of the work on agronomic production of the perennial poppy for the alternate source of codeine, medicinal codeine, I did much of that research in my project. And the stimulus was the typical thing of USDA involvement by political reaction or pressure. In this case, it was just State Department drug enforcement pressure to look for an alternate source of opium to help get away from the hazards of illegal use of opium.

And so, again, there the USDA was involved as long as the State Department put the pressure on. And then there was nothing to really get over some of the political as well as agronomic and other commercial barriers, and so it kind of just died a typical slow death.

Senator CONRAD. Because there was not a structure like this one to help pick up the ball?

Dr. JOLLIFF. Right. I think in that particular case something like ARCC might have been involved even with the Department of State, trying to say, OK, now really rather than some individual or like the company Mallincrodt was the drug company that was wanting to get involved in it, and the barriers just kept coming up. And so I think they just gave up after awhile.

I think of the question of crambe. You know it is interesting that it is a common topic here. My predecessor 25 years ago was working on that in Oregon. He never had enough funding to even have a research technician plus I mean a full-time technician during most of those years.

He also was the one who worked along. He was encouraged by the scientists at USDA Peoria to begin looking at industrial rapeseed. That was 25 years ago when he had people going crambe in Oregon.

There is still a joke in Oregon about farmers with crambe in their bins. The farmers are ready to grow stuff if you can just give them something that will make them a little bit of money. And so he sort of shipped all the crambe off to Indiana, and they decided that rapeseed might be a better product to work on.

And he worked on it for 10 or 15 years and improved the germ plasm for the industrial variety of rapeseed. In fact, I released that cultivar as germ plasm which Dr. Auld in Idaho has used to develop the materials that are being grown right now. But I could not get funding for rapeseed research.

Senator CONRAD. Well, I tell you, the Canadians did not show any of that resistance; right? The Canadians, I tell you, ran with it. As a result, they beat us to the punch, over and over. How many times have we seen this happen?

Dr. JOLLIFF. Significant internal political lobbies against rapeseed because it was an oilseed. And then Japan came to the Northwest to generate and stimulate the interest to get U.S. competition in the rapeseed market. And now who benefits? Japan. They know how to work the whole world. So those stories just go on and on and on.

Senator CONRAD. Well, I want to thank you for those illustrations. That is exactly what I was looking for in terms of fleshing out the record here. Again, we are almost at 5:30, and there is a vote scheduled at 5:30. So I am going to bring this hearing to an end.

Again, I just want to very much thank all of those who have come and testified today. I especially want to thank those who have testified in support of this concept. But I do thank everybody who has testified here today.

I think we have received some ideas that will be very helpful to improving this legislation, and I very much appreciate any help you can provide in convincing my colleagues that this is something we ought to proceed with.

I think that the work of the task force was excellent. It was superb. In fact, it was, to my way of thinking, the very best that you can ask for from a task force. They did not limit themselves with mastering the rut.

They looked for a big opportunity, and then were practical and specific about how to take advantage of an opportunity. And that is the best we can ask for, and I think we owe it to that group to try to implement their idea and their vision, because that really is what it is. It is a vision. Yes, Gary.

Dr. JOLLIFF. Mr. Chairman, I, just for the record, would like to say that I think Dr. Ronald Sampson is probably the most capable individual I have ever worked with in my professional career. I just am amazed at the way he brought that task force together, and he certainly deserves a lot of credit.

Senator CONRAD. Well, I recognize as chairman of the task force the work that he must have done. This really is an exceptional product, I think. I think anybody that was involved in that can be extremely proud of what they did. I think before long we are going to see the kernel of the idea adopted as law in this country.

I am absolutely committed to that. So, again, thank all of you for the contribution you have made here today. We will declare this hearing closed.

[Whereupon, at 5:25 p.m., the subcommittee adjourned, subject to the call of the Chair.]

[Material submitted for inclusion in the record follows:]

II

100TH CONGRESS
2D SESSION

S. 2413

To establish regional centers for the commercial development of new industrial farm and forest products, and for other purposes.

IN THE SENATE OF THE UNITED STATES

MAY 19 (legislative day, MAY 18), 1988

Mr. CONRAD (for himself, Mr. ADAMS, Mr. BURDICK, Mr. DASCHLE, Mr. FOWLER, Mr. GLENN, Mr. HARKIN, Mr. KENNEDY, and Mr. PRYOR) introduced the following bill; which was read twice and referred to the Committee on Agriculture, Nutrition, and Forestry

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A BILL

To establish regional centers for the commercial development of new industrial farm and forest products, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Agricultural Research Commercialization Act of 1988".

SEC. 2. FINDINGS.

Congress finds that—

(1) the United States has available a tremendous wealth of renewable resources, rainfall, climate, soil, and skilled agricultural producers;

(2) the agricultural sector and rural areas of the United States continues to experience depressed conditions;

(3) there is a demonstrated need for rural economic development in order to bring profitability back into the agricultural sector and bring jobs back into rural areas;

(4) domestic agricultural commodities are confronting strong competition in world markets;

(5) as a consequence of strong foreign competition, utilization of United States agricultural exports is shrinking, resulting in lower commodity prices and lower profitability for agriculture and related industries;

(6) new and emerging technologies, such as bioengineering and biotechnology, and other such innovations offer great potential for the development of new agricultural products and processes suitable for industrial and other non-food and non-feed uses;

(7) industrial products and processes developed from new technologies will contribute substantially to the economic stability and well-being of the rural econ-

omy and to the favorable competitive position of the United States in foreign markets;

(8) the development, commercialization, and marketing of new non-food, non-feed or industrial products is both financially costly and unusually risky;

(9) the private financial sector often does not provide adequate capitol for the high risk commercialization and marketing of new products;

(10) the United States spends over $2,000,000,000 per year on agricultural research;

(11) many of the emerging new ideas, products, and processes resulting from agricultural research have never been commercialized because of the high initial financing costs and high risk; and

(12) the careful targeting of financial assistance to entrepreneurs for the commercialization of new industrial uses of agricultural and forestry products will be a cost effective means of stabilizing the agricultural sector and redeveloping the rural economy.

SEC. 3. PURPOSE.

It is the purpose of this Act through the Corporation established pursuant to section 5—

(1) to commercialize new non-food, non-feed uses for traditional and new agricultural crops in order to enhance and stabilize the economic development of the

rural economy, and to diversify markets for raw agricultural and forestry products;

(2) to identify the results of private and public agricultural research with the potential for the development and commercialization of new non-food, non-feed products and processes;

(3) to encourage cooperative development and marketing efforts among manufacturers, financiers, universities, and private and government laboratories in order to accelerate the commercialization of new industrial uses for agricultural and forestry products;

(4) to emphasize the development and marketing of new uses and new forms of farm and forest products and by-products, rather than increasing the productivity of established crops;

(5) to direct, to the maximum extent possible, commercialization efforts toward the development of new products from crops that can be raised by family-sized farmers;

(6) to disseminate (to the extent limited by proprietary rights) the results of development projects in order for the public to benefit from the programs authorized under this Act; and

(7) to provide financing mechanisms to accomplish the activities described in paragraphs (1) through (6).

SEC. 4. DEFINITIONS.

As used in this Act:

(1) CORPORATION.—The term "Corporation" means the Agricultural Research Commercialization Corporation established in section 5.

(2) CORPORATE BOARD.—The term "Corporate Board" means the Board of Directors established pursuant to section 9.

(3) COMMERCIALIZATION.—The term "commercialization" or "commercialize" includes—

(A) activities associated with the development of prototype products or industrial plants;

(B) the application of technology and techniques to the development of industrial production; and

(C) the market development of new industrial uses of new and traditional agricultural and forestry products and processes, that will lead to the creation of goods and services that may be marketed for profit.

Universities or other non-profit organizations are not excluded from participation in the activities described in this paragraph.

(4) REGIONAL CENTERS.—The term "Regional Centers" means the Centers established pursuant to section 7.

(5) SECRETARY.—The term "Secretary" means the Secretary of Agriculture.

SEC. 5. ESTABLISHMENT OF CORPORATION.

(a) ESTABLISHMENT.—There is established within the Department of Agriculture an independent non-profit corporation to be known as the "Agricultural Research Commercialization Corporation".

(b) CENTRAL OFFICE.—The Secretary shall provide facilities for the principal office of the Corporation within the National Agricultural Library at the facilities located in Beltsville, Maryland.

(c) PLACE OF INCORPORATION.—The Corporation shall be incorporated in the District of Columbia and be considered a resident of such.

(d) ESTABLISHMENT OF REGIONAL CENTERS.—The Corporation shall establish a minimum of 10 and a maximum of 12 Regional Centers in the United States as provided for in section 7.

SEC. 6. POWERS OF THE CORPORATION.

(a) GENERAL POWERS.—In carrying out the provisions of this Act, the Corporation shall have the power—

(1) to adopt, alter, and rescind bylaws and to adopt and alter a corporate seal, which shall be judicial noticed;

(2) to make agreements and contracts with persons and private or governmental agencies, except that the Corporation shall not provide any financial assistance unless specifically permitted under this Act;

(3) to lease, purchase, accept gifts or donation of, or otherwise to acquire, and to use, own, hold, improve, or otherwise deal in or with, and to sell, convey, mortgage, pledge, lease, exchange, or otherwise dispose of, any property, real, personal, or mixed, or any interest therein;

(4) to sue and to be sued in its corporate name and to complain and defend in any court of a competent jurisdiction;

(5) to represent itself, or to contract for representation, in all judicial, legal, and other proceedings, except actions cognizable under the Federal Tort Claims Act (28 U.S.C. 2671 et seq.), in which actions it will be represented by the Attorney General;

(6) subject to provisions of this Act, to select, employ, and fix the compensation (including, without limitation, pension plan, health benefits, incentive compensation plan, paid vacation, sick leave, and other fringe benefits) of such officers, employees, attorneys and agents as shall be necessary for the transaction of the business of the Corporation;

(7) to make provision for and designate such committees, and the functions thereof, as the Board of Directors may deem necessary or desirable;

(8) to indemnify Directors and officers of the Corporation, as the Board of Directors may deem necessary or desirable;

(9) with the approval of the agency concerned, to make use of services, facilities, and property of any board, commission, independent establishment, or executive agency or department of the executive branch in carrying out the provisions of this Act and to pay for such use, such payments to be credited to the applicable appropriation that incurred the expense;

(10) to obtain the services and fix the compensation of consultants;

(11) to use the United States mails on the same terms and conditions as the executive departments of the United States Government; and

(12) to exercise all other lawful powers necessarily or reasonably related to the establishment of the Corporation, to carry out the provisions of this Act and the exercise of its powers, purposes, functions, duties, and authorized activities.

(b) GOVERNMENT CORPORATE CONTROL ACT.—The Corporation shall be considered a wholly-owned corporation for the purposes of the Government Corporate Control Act.

SEC. 7. REGIONAL CENTERS.

(a) LOCATION.—

(1) IN GENERAL.—Each Regional Center established by the Corporation pursuant to section 5(d) shall be located in a different State, which is, to the maximum extent possible, representative of the climate, geography, soil, and water conditions of the region to be served by such Center.

(2) REGIONS.—The Corporation shall establish a Regional Center to serve—

(A) the Northern Plains, which shall include Minnesota, Montana, North Dakota, South Dakota, and Wyoming;

(B) the Eastern Corn Belt, which shall include Illinois, Indiana, Michigan, and Wisconsin;

(C) the Western Corn Belt, which shall include Iowa, Kansas, Missouri, and Nebraska;

(D) the Pacific region, which shall include Alaska, California, Hawaii, Oregon, and Washington;

(E) the Mountain States, which shall include Arizona, Colorado, Idaho, Utah, and Nevada;

(F) the Southern Plains, which shall include Oklahoma, Texas, and New Mexico;

(G) the Northeast region, which shall include Connecticut, Maine, Massachusetts, New Hampshire, New York, and Vermont;

(H) the Eastern Midsection region, which shall include Delaware, New Jersey, Pennsylvania, Ohio, and West Virginia;

(I) the Border South region, which shall include Kentucky, North Carolina, Tennessee, South Carolina, and Virginia;

(J) the Deep South, which shall include Alabama, Arkansas, Georgia, Louisiana, and Mississippi; and

(K) two additional areas if Centers are determined to be necessary in such areas by the Board of Directors of the Corporation, to be established as determined by the Board of Directors.

(b) ACTIVITIES.—Each Regional Center shall carry on activities provided for in this Act and such other activities as the Board of Directors shall from time to time delegate to such Centers.

(c) REGIONAL DIRECTOR.—

(1) APPOINTMENT.—Each Regional Center shall be headed by a full-time Regional Director who shall be appointed by the Secretary.

(2) QUALIFICATIONS FOR SELECTING REGIONAL DIRECTORS.—The individual selected to be the Regional Director for each Regional Center must meet one or both of the following qualifications:

(A) Such individual shall have a scientific or engineering background.

(B) Such individual shall have experience in the development of new products or processes in the public or private sector.

(d) ADVISORY COUNCILS.—

(1) APPOINTMENT.—The Corporate Board shall appoint an Advisory Council for each Regional Center and such Council shall advise the Regional Director concerning all activities carried on by the Regional Center.

(2) COMPOSITION OF ADVISORY COUNCILS.—The Advisory Council shall be comprised of representatives of the public sector, the financial sector, the private business community (both high-tech and mature industries), the labor sector, State and local governments, universities, colleges, technical colleges, vocational

schools, private and Federal laboratories, the farming sector, scientists, and engineers.

(3) DUTIES OF THE ADVISORY COUNCIL.—The primary duty of the members of the Advisory Council shall be to review or coordinate the peer review of the technical, engineering, financial, and managerial soundness and marketing potential of the applications for assistance.

SEC. 8. ACTIVITIES OF THE REGIONAL CENTERS.

The Regional Centers shall—

(1) encourage interaction among private and Federal laboratories, National Science Foundation centers, Department of Agriculture research programs, and other Federal resources, State and local regional economic development programs, universities, colleges, the private sector and the financial community, for the purpose of evaluating and commercializing new, non-food, non-feed uses of agricultural and forestry products;

(2) identify broad areas where commercialization of new products and processes can contribute to the economic growth of the United States, through the development of new, non-food, non-feed uses for farm and forest products by private companies and businesses;

(3) encourage cooperative associations of universities, private enterprises, and/or Federal laboratories for the purpose of coordinating research and development programs that will aid in the creation of new technologies and processes using agricultural and forestry inputs;

(4) provide technical assistance and related business and financial counseling for small American businesses to commercialize new, non-food, non-feed uses of agricultural and forestry products;

(5) identify new non-food, non-feed products and processes which are worthy of financial assistance;

(6) advise universities of the research needs of the private sector and improve the exchange of scientific and technological information for the mutual benefit of universities and private business;

(7) disseminate information on its commercialization projects in order that the public shall benefit from the activities of the Regional Centers, except that the proprietary rights of individuals or businesses are respected;

(8) make use of existing programs in scientific, engineering, technical and management education which will support the accelerated commercialization of new,

non-food, non-feed products and processes using farm and forest products;

(9) determine how public universities can increase income derived from the sale or licensure of new non-food, non-feed products or processes that have commercial value; and

(10) advise the Corporation on the viability of specific proposals submitted for financial assistance and on the type of assistance, if any, to be provided.

SEC. 9. CORPORATE BOARD OF DIRECTORS.

(a) MEMBERSHIP.—

(1) IN GENERAL.—The Corporate Board shall consist of 25 members of which—

(A) 10 members shall be the 10 Regional Directors; and

(B) the remaining 15 members shall be appointed by the Secretary.

(2) EXPERIENCE.—In appointing the members to the Corporate Board under paragraph (1), the Secretary shall assure that—

(A) the Regional Directors have experience in the development of new technologies; and

(B) the members appointed under subparagraph (B) are representative of the agricultural, scientific, financial, and managerial community.

(3) CHAIRPERSON.—The Corporate Board shall elect a Chairperson from among the members of the Corporate Board who are not Regional Directors.

(b) TERM OF OFFICE.—

(1) IN GENERAL.—Members of the Corporate Board shall be appointed for a term of 5 years.

(2) STAGGERED TERMS.—Members of the Corporate Board shall serve staggered terms. The Secretary shall designate five members of the Corporate Board to be up for reappointment in one year, followed by five members so designated in each of the next years.

(3) REMOVAL.—A Director may be removed from office by the Secretary only for neglect of duty, or malfeasance in office.

(c) OATH AND CITIZENSHIP.—Before assuming office, each member of the Corporate Board shall take an oath to faithfully discharge the duties of the individual's position as a member of such Board, and be a citizen of the United States.

(d) MEETINGS, QUORUM, ACTIONS.—

(1) MEETINGS.—The Corporate Board shall meet as may be provided by the bylaws of the Corporation, and at any time pursuant to the call of the Chairperson, but the Board shall not meet less than twice annually to review financial applications.

(2) QUORUM AND ACTIONS.—A majority of the Corporate Board members shall constitute a quorum, and any action by such Board shall require a majority vote of all members of the Board.

(e) PUBLIC MEETINGS.—

(1) IN GENERAL.—Except as provided in paragraph (2), all meetings of the Corporate Board held to conduct the official business of the Corporation shall be open to public observation, and shall be preceded by reasonable public notice.

(2) CLOSED MEETINGS.—Pursuant to the bylaws of the Corporation, the Corporate Board may hold a closed meeting if the Chairperson determines that the meeting is likely to disclose—

(A) information that is likely to adversely affect financial or securities markets or institutions;

(B) information, the premature disclosure of which would be likely to—

(i) violate proprietary rights of individuals; or

(ii) impede on an individual's ability to negotiate a contract for financial assistance; or

(C) matters or information exempted from public disclosure pursuant to paragraph (1), (2), (4), (5), or (6) of subsection (c) of section 552b, title 5, United States Code.

SEC. 10. POWERS AND DUTIES OF CORPORATE BOARD.

(a) Powers.—

(1) Vesting.—The powers of the Corporation shall be vested in the Corporate Board.

(2) Chief executive.—The Chairperson of the Corporate Board shall be the chief executive officer of the Corporation, and shall be responsible for the management and direction of the Corporation on a full-time basis.

(3) Officers.—The Corporate Board shall establish the offices and appoint the officers of the Corporation, which shall include a General Counsel and Treasurer, and define the duties of such offices.

(b) Delegation of Authority.—

(1) Corporate board.—The Corporate Board may, by resolution, delegate to the Chairperson and any other directors any functions, powers and duties assigned to the Corporation under this Act other than those expressly vested in the Corporate Board.

(2) Chairperson.—The Chairperson may, by written instrument, delegate such functions, powers,

and duties as are assigned to the Chairperson pursuant to the provisions of this Act, to such other directors, officers, or employees of the Corporation as the Chairperson considers appropriate.

(c) Delegation Not Permitted.—

(1) In general.—Notwithstanding any other provision of law, the Secretary and any other officer or employee of the United States shall not make any delegation to the Corporate Board, the Chairperson, or to the Corporation of any power, function, or authority not expressly authorized by the provisions of this Act, except where such delegation is pursuant to an authority in law which expressly makes reference to this section.

(2) Reorganization act.—Notwithstanding any other provision of law, chapter 9 of title 5, United States Code, shall not apply to authorize the transfer to the Corporation of any power, function, or authority.

(d) Bylaws.—The Corporate Board shall adopt, and may from time to time amend, such bylaws as are necessary for the proper management and functioning of the Corporation.

(e) Organization.—The Corporate Board shall provide a system of organization to fix responsibility and promote efficiency.

(f) EXEMPTION FOR CERTAIN LAWS.—Except as specifically provided for in this Act, directors, officers, and employees of the Corporation shall not be subject to any law of the United States relating to governmental employment.

(g) HIRINGS AND DISCHARGES.—

(1) IN GENERAL.—The Chairperson shall appoint such employees as the Corporate Board may authorize to carry on the business of the Corporation. The Chairperson may discharge such employees from such positions in accordance with this section.

(2) LIMITATION.—The Corporation shall not be authorized to employ more than 70 full-time equivalent professional positions at any time.

(h) POLITICAL QUALIFICATIONS.—No political test or qualifications shall be used in selecting, appointing, promoting, or taking other personnel actions with respect to officers, agents, and employees of the Corporation.

SEC. 11. COMPENSATION.

(a) CORPORATE BOARD.—

(1) IN GENERAL.—Members who serve on the Corporate Board shall receive compensation at a rate of $5,000 annually, as well as reasonable expenses incurred in carrying out the business of the Corporation, as approved by the Corporate Board.

(2) CHAIRPERSON.—The Chairperson of the Corporate Board, as the full-time chief executive officer, shall be compensated at a rate in accordance with section 11(c).

(b) REGIONAL DIRECTOR.—The Regional Director of each Regional Center shall be compensated at a rate in accordance with section 11(c).

(c) OFFICERS AND EMPLOYEES.—The Corporate Board shall—

(1) fix the rate of compensation for individual officer positions and categories of other employees of the Corporation taking into the consideration the rates of compensation in effect under the Executive Schedule and the General Schedule prescribed by subchapters II and III of chapter 53 of title 5, United States Code, for comparable positions or categories; and

(2) if determined necessary by the Board and approved by the Secretary, fix the rate of compensation of any officer position or category of other positions at a rate or rates in excess of that prescribed for level I of the Executive Schedule under section 5312 of title 5, United States Code.

SEC. 12. FINANCIAL DISCLOSURE AND CONFLICTS OF INTEREST.

(a) FINANCIAL DISCLOSURE.—The financial disclosure provisions of the Ethics in Government Act of 1978 (2 U.S.C. 701 et seq.) applicable to individuals occupying positions compensated under the Executive Schedule shall apply to the Directors and officers of the Corporation and to employees of the Corporation whose position in the schedule established by the Board of Directors pursuant to section 11(c) is compensated at a rate equivalent to that payable for grade GS-16 or above of the General Schedule established by chapter 53 of title 5, United States Code. The financial disclosure provisions of the Ethics in Government Act shall apply to the Corporation as it were a Federal agency.

(b) POST-FEDERAL EMPLOYMENT.—Any provision of law governing post-Federal employment activities shall not apply to former Federal employees who may be employed by the Corporation to act on behalf of the Corporation.

(c) CONFLICTS OF INTEREST.—

(1) IN GENERAL.—Except as permitted in paragraph (3), no member of the Corporate Board shall vote on any matter respecting any application, contract, claim, or other particular matter pending before the Corporation, in which, to the knowledge of the member, such member, spouse or minor child of such member, partner or organization (other than the Cor-

poration) in which such member is serving as officer, director, trustee, partner, or employee, or any person or organization with whom such member is negotiating or has any arrangement concerning prospective employment, has a financial interest.

(2) Removal.—Action by a member of the Corporate Board that is contrary to the prohibition contained in paragraph (1) shall be cause for removal of such member pursuant to the powers of the Corporation in section 6, but shall not impair or otherwise affect the validity of any otherwise lawful action by the Corporation in which the member or officer participated.

(3) Informed consent.—The prohibitions contained in paragraph (1) shall not apply if the member of the Corporate Board advises the Board of the nature of the particular matter in which such member proposes to participate in, and if such member makes a full disclosure of such financial interest, prior to any participation, and the Corporate Board determines, by majority vote, that the financial interest is too remote or too inconsequential to affect the integrity of such member's services to the Corporation in that matter. The member involved shall not participate in such determination.

(d) CRIMINAL PUNISHMENT.—Section 207(a) of title 18, United States Code (and subsections (f), (h), and (j) of such section, to the extent such subsections relate to subsection (a)) shall apply to former directors, officers, and employees of the Corporation as if they were former officers or employees of the executive branch of the United States Government. Such section shall apply to the Corporation as if it were an agency of the executive branch of the United States Government.

SEC. 13. AUTHORIZATION OF ADMINISTRATIVE EXPENDITURES.

(a) CORPORATE EXPENDITURES.—In each fiscal year the Corporation is authorized to expend amounts for—

(1) reasonable and necessary administrative expenses, not to exceed 5 percent of amounts appropriated in any fiscal year; and

(2) generic studies and specific reviews of individual proposals for financial assistance, which shall not exceed ½ of 1 percent of amounts appropriated in any given year.

(b) ADMINISTRATIVE EXPENDITURES.—For purposes of this section, administrative expenditures shall include—

(1) all ordinary and necessary expenses, including all compensation for personnel and consultants, ex-

penses for computer usage, or space needs of the Corporation and similar expenses; and

(2) reimbursement to members of the Corporate Board for reasonable expenses which are incurred in connection with the service of the Corporation.

(c) LIMITATION.—Expenditures authorized under subsection (a)(2) shall not be available—

(1) for administrative expenses;

(2) for the reimbursement of governmental agencies for the salaries of personnel of such agencies detailed to the Corporation;

(3) to exceed the personnel limits established pursuant to section 11(c)(2); or

(4) for operating expenses.

(d) REAL PROPERTY.—Funds authorized for administrative expenditures shall not be available for the acquisition of real property.

(e) ADMINISTRATION EXPENSES CONSIDERATIONS.—The Corporation's expenditures for administrative expenses shall reflect due consideration for economy and efficiency.

SEC. 14. PUBLIC ACCESS TO INFORMATION.

(a) IN GENERAL.—The Corporation shall make available to the public, on request, any information regarding its organization, procedures, requirements, and activities. The Corporation is authorized to withhold information which is exempted from disclosure pursuant to subsection (b) of section 552 of title 5, United States Code, and section 9(e) of this Act as such pertains to minutes of meetings of the Board of Directors.

(b) DETERMINATION BY CORPORATION.—

(1) IN GENERAL.—The Corporation, on receipt of any request for information, shall determine promptly whether to comply with such request and shall promptly notify the person making the request of such determination.

(2) REVIEW OF DETERMINATION.—In the event of an adverse determination, and if requested by the person requesting the information, such determination shall be reviewed by the General Counsel of the Corporation.

(c) CRIMINAL SANCTIONS.—Section 1905 of title 18, United States Code, shall apply—

(1) to Directors, officers, and employees of the Corporation as if they were officers or employees of the United States; and

(2) to the Corporation as if it were a Federal agency.

SEC. 15. FINANCIAL ASSISTANCE.

(a) IN GENERAL.—The Corporation, through the Regional Directors, in accordance with the criteria provided for in section 16, shall provide financial assistance through grants, repayable grants, long-term low interest loans, and loan guarantees to projects commercializing new, non-food, non-feed products using agricultural and forestry commodities.

(b) DETERMINATION OF TYPE.—The Corporate Board, at the discretion of the Board, may provide any of the following types of assistance to successful applicants:

(1) Loans at low interest rates.

(2) Grants that are matched by private or local public funds.

(3) Repayable grants that are matched by private or local public funds and which are repaid out of gross revenue from the sale of the product as agreed in a contract between the Corporation and entrepreneur.

(4) Guarantees of loans made by private financial institutions.

(c) PROPRIETARY RIGHTS.—The Corporation shall not receive proprietary or patent rights to any proposal in return for financial assistance.

SEC. 16. ELIGIBILITY CRITERIA FOR FINANCIAL ASSISTANCE.

(a) IN GENERAL.—To obtain financial assistance from the Corporation, an entity shall file an application with the Regional Director of the appropriate Regional Center.

(b) APPLICATION.—An application submitted to the Regional Director under subsection (a) shall—

(1) describe the proposal of the entity for the commercialization of a new product consistent with this Act, including documentation that such proposal is—

(A) scientifically sound;

(B) technologically feasible; and

(C) marketable;

(2) provide documentation that adequate private sector funding is not available, but that the applicant has the ability to obtain matching funds from the public or private sectors;

(3) provide documentation that the applicant's own resources, including time and money, have been invested in the project;

(4) provide documentation that the product or process has broad application and has the potential to be commercially viable without continual assistance;

(5) provide documentation that the proposal has broad participation by representatives of the sectors described in section 7(d)(2);

(6) provide documentation that the managerial ability or established relationship exists between the applicant and other entities to give the applicant access to private business assistance;

(7) provide assurances of legal compliance by the applicant with the terms and conditions of the receipt of assistance under this Act; and

(8) provide assurances that the proposal will result in the creation of new jobs.

(c) STATE PARTICIPATION.—A proposal which can show proof of actual or promised State or local government financial participation shall receive priority over a proposal which cannot show such public sector involvement.

(d) PRIVATE PARTICIPATION.—A proposal which can show proof of actual or promised private financial participation shall receive priority over a proposal which cannot show such private sector involvement.

(e) APPLICATION REVIEW PROCESS.—

(1) IN GENERAL.—The Regional Directors shall work in consultation with the staff, the Advisory Council, and the peer review members to evaluate the proposals submitted to the Regional Centers.

(2) STAFF.—The staff of the Regional Center, on receipt of an application under this section, shall evaluate the proposals made, and materials contained, in the application and submit its recommendations to the Regional Director and the Advisory Council.

(3) ADVISORY COUNCIL.—The Advisory Council shall review the proposal, assisted by the peer review.

The Advisory Council shall, by majority vote, make a non-binding recommendation on the proposal to the Regional Director.

(4) REGIONAL DIRECTOR.—The Regional Director, on consideration of the Advisory Council's recommendation and on peer view comments, shall make and submit the Director's recommendation to the Corporate Board along with the recommendation of the Advisory Council.

(5) CORPORATE BOARD.—The Corporate Board shall, by majority vote, make the final decision on whether and how to provide assistance to the applicant.

SEC. 17. REPAYMENT OF FINANCIAL ASSISTANCE.

(a) SUCCESSFUL ENTITIES.—Entities that succeed in marketing new, non-food, non-feed products and processes through the use of repayable grants provided under this Act shall repay to the Regional Center the amount of such financial assistance based on a percentage of the gross sales of such entity as contracted between the Corporation and the entity. Loans shall be repaid as specified in the contract between the Corporation and the entity.

(b) NONSUCCESSFUL ENTITIES.—Entities which do not succeed in marketing new, non-food, non-feed products and processes through the use of financial assistance provided under this Act shall not be required to repay the Regional Center for such financial assistance, except that the entity shall be required to transfer to the Corporation any collateral pledged to obtain the loan, loan guarantee, or repayable grant.

(c) GUIDELINES.—The Corporation, in consultation with the Secretary and the appropriate committees of Congress, shall issue guidelines to enable the Regional Centers to determine whether a project is successful.

SEC. 18. REVOLVING FUND.

(a) ESTABLISHMENT.—There is established a revolving fund to be administered by the Secretary as provided for in this Act.

(b) CONTENTS.—Funds received by the Regional Centers under section 17(a) as a result of any loan or grant made pursuant to the provisions of this Act, shall be covered into and become a part of the revolving fund established under subsection (a).

(c) USE OF FUND.—The contents of the revolving fund established under subsection (a) shall be used by the Corporation to provide financial assistance under section 15, and to pay for the costs of operation as provided for in section 6(a).

(d) REGIONAL REVOLVING FUNDS.—

(1) ESTABLISHMENT.—The Corporation may establish a revolving fund in one or more of the areas

served by the regional centers established under section 7(a).

(2) CONTENTS.—Amounts contained in such revolving funds shall be derived from contributions from commodity groups, funds received through State tax check-off programs, or funds received from other independent sources.

(3) USE OF FUND.—The contents of the revolving fund established under paragraph (1) shall be used by the Regional Center for such region to pay for the costs of operation and the activities described in section 8, and to provide financial assistance of the type described in section 15.

SEC. 19. AUTHORIZATION OF APPROPRIATIONS.

(a) IN GENERAL.—There is authorized to be appropriated such sums as may be necessary in each of the fiscal years 1989 through 1999 to carry out the purposes of this Act. Amounts appropriated shall be available to each Regional Center in proportion to each Region's share of the gross agricultural sales of the United States, to provide financial assistance for the development of new, non-food, non-feed industrial uses for farm and forest products.

(b) TRUST FUND.—The Secretary may set up a trust fund of up to $1,000,000,000 to finance the Corporation on a continuing basis.

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